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An Overview of Aridland Ciénagas, with Proposals for Their Classification, Restoration, and Preservation

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Abstract

Ciénagas are the American Southwest's most unusual wetlands, yet they are dwindling. This paper addresses what they are, their uniqueness and importance, how they developed, and the causes for the loss of most ciénaga habitat. We also propose a classification system for ciénagas that will contribute to a more meaningful and better-focused discussion about ciénagas, provide an inventory of known ciénagas, and suggest a system of Ciénaga Coordinators with the goal of identifying, restoring, and preserving the few remaining ciénagas. Finally, the inventory from this paper is made available online in an interactive, open, moderated format that will allow anyone to contribute to the correction, evolution, and general improvement and growth of this database, and to download and use the content. A link to this system can be found in a permanent archive of this paper at http://hdl.handle.net/2152/30285.

Introduction

The general public knows what rivers are, and even people unconcerned about the environment understand the importance of drinking water and watercourses such as rivers, creeks, streams, and brooks. But there is a unique wetland in the American Southwest that not many people know at all: the aridland ciénaga. Few uncompromised ciénagas remain functional, and, absent an awareness of what and how important they are, we may soon see these endangered wetlands become extinct. The Endangered Species Act does not yet protect habitats independently of individual species, but if it did, ciénagas would undoubtedly receive protection. *Ciénaga* is a Spanish term used in the Southwest for a silty marshy area, a bog, or a shallow, slow-moving flow of water through dense surface vegetation (Hendrickson and Minckley 1985; Minckley et al. 2009). We provide a discussion of the source and alternate spellings and punctuation of this term in Appendix A.

Our interest in ciénagas emerged from an undertaking to restore the 14.48-km (9-mi), severely incised—deeply down-cut or eroded by rapid water flows—reach of the Burro Cienaga on the Pitchfork Ranch in Grant County, New Mexico, in the southwest corner of the state (Cole and Cole 2010; Helbock and Cole 2014). In this paper, we answer the following questions about this imperiled ecosystem: What is a ciénaga? How and when did ciénagas form, what damaged them, what were their historic numbers, how much or what percentage of ciénaga habitat remains, and why are ciénagas important to the Southwest? Will a ciénaga classification system and the creation of Ciénaga Coordinators help to restore and preserve them?

Ciénagas Defined

Undamaged ciénagas are freshwater or alkaline wet meadows with shallow-gradient, permanently saturated soils in otherwise arid landscapes that in earlier time supported lush meadow grasses and often occupied the entire widths of valley bottoms. Ciénagas occur because the geomorphology forces water to the surface, and historically they covered large areas rather than occurring as single pools or channels (Hendrickson and Minckley 1985; Sivinski and Tonne 2011). Ciénagas are usually associated with seeps or springs and are occasionally found in canyon headwaters or along the margins of streams (Sivinski and Tonne 2011). In a healthy ciénaga, water slowly migrates through long, wide mats of thick, sponge-like wetland sod. Ciénaga soils are squishy, permanently saturated, organic, anaerobic, and black.

Highly adapted grasses (Poaceae), sedges (Cyperaceae), and rushes (Juncaceae) are the dominant plants in ciénagas, with riparian tree species—Goodding's willow (*Salix gooddingii*), Fremont's cottonwood (*Populus fremontii*), and scattered Arizona walnuts (*Juglans major*)—found along drier margins or down-valley where the ciénaga ends and water disappears underground. The telltale signs of an aridland ciénaga are ground-fed persistent water, gray or oxidized soils, soil fines (silts, clay, and organic particles) or near fines, and often the occurrence of plants endemic to ciénagas.

Since the late 1800s, many of these ciénagas have lost their instream or wetland function; unincised ciénagas are essentially nonexistent today (Minckley et al. 2009) and most ciénagas are substantially reduced in size, with successional tree species common along deeply cut channels due to the ongoing, region-wide erosion that followed the arrival of Europeans (Fig. 1). As described below, the misuse of land by frontiersmen entrenched water flow between what became vertical walls and established incisions that have resulted in an ever-worsening erosive process and drawdown of local water tables (Fig. 2). Some southwestern ciénagas have simply dried up because their aquifers were captured and depleted for farming or industrial purposes (Sivinski and Tonne 2011). This pervasive drying of most marshland environments left behind few ciénagas and those that survived are significantly reduced in size. Many of the remaining ciénagas look and function like creeks: narrow, incised, and continuing to de-

Fig. 1. **Looking down-channel, creek-like portion of the Burro Cienaga, Pitchfork Ranch, Grant County, in southwest New Mexico. Photo: Dennis O'Keefe (2008).**

grade (Fig. 3). Since the late 1800s, natural wetlands in arid and semi-arid desert grasslands of the American Southwest and Northern Mexico have largely disappeared (Minckley and Brunelle 2007).

Hendrickson and Minckley (1985) first alerted the Southwest academic world to the importance of the region's overlooked ciénagas. Prior to that time, many believed that the only good wetland was a drained wetland (McCool 2012). However, since Hendrickson and Minckley's (1985) rather inauspicious invitation for further study of ciénagas, the efforts to understand and restore them have gained prominence.

A sense of how poorly ciénagas had been viewed historically can be gleaned from a remark made during the naming of Silver City, New Mexico. When city fathers met in 1870 to choose a name for the community occupying the once unmolested *La Ciénega de San Vicente,* a lengthy discussion finally reached consensus to discard *San Vicente* and to call their new town *Silver City*. Upon hearing the choice, one of the men in attendance remarked: "It was one hell of a name to call a town on a mud flat" (Alexander 2005, 89).

Similarly, consider this excerpt from the beloved New Mexico novel *Red Sky at Morning* (Bradford 1968). In this 1940s-era conversation between the narrator, Joshua Arnold, and his classmate, this exchange occurs (p. 86):

> "I didn't know there was this much water around Sagrado . . . [t]he Sagrado River's been dry since I got here."
>
> "This is a *cienega*," Parker said. "It's some kind of underground spring, but it's not good for anything but making the ground wet. Costs a fortune to drain it or pump it off, and Cloyd isn't about to spend money for things like that."

The ciénagas discussed here are not to be confused with typical wetlands found throughout the North American continent. What distinguishes "aridland ciénagas" is their location in deserts and their association with groundwater discharge—springs and groundwater seeps in otherwise arid lands—which lends them a large degree of permanence, biogeographic isolation, and stability.

Ciénagas are commonly overlooked but are an important subset of wetlands in the North American Southwest. A recent study (Dahl 2011) looked at the extent and habitat type of wetlands throughout the conterminous United States and concluded that there were an estimated 44.6 million ha (110.1 million ac) of wetland habitat. Despite this comprehensive survey and detailed treatment of a wide variety of wetlands—freshwater and saltwater, marshes and ponds, and even descriptive types such as prairie pothole wetlands—the report makes no mention of ciénagas.

Southwest aridland ciénagas discussed here differ from the ciénaga wetlands of Colombia and other South American countries. There are many dozens of wetlands bearing the name "ciénaga," covering more than 7,800 km (4,847 mi) in Colombia alone (Subgerencia Cultural del Banco de la República 2005), but those are not the desert groundwater-fed ciénagas of the Southwest. The Colombian ciénagas represent different wetland systems altogether. Perhaps those studying ciénagas would do well to refer to the ciénagas mentioned in the Southwest as "aridland ciénagas," thereby avoiding confusion with high-mountain wet meadows and other wetland ciénagas elsewhere that function differently.

Fig. 2. **The eight-foot wall shown here, down-channel right, is typical of the incision damage in many ciénagas. This pool, not a typical feature in a healthy ciénaga, is located in kilometer 1 of the 14 km (9 mi) Burro Cienaga reach on the Pitchfork Ranch. Photo: Cinda Cole (2005).**

Fig. 3. Looking up-channel, a short section of the approximately 3.2 km (2 mi) ciénaga portion of the 14.48 km (9 mi) reach of the Burro Cienaga (full course is 747.2 km, 47.6 mi) on the Pitchfork Ranch, is the result of redirecting the broad ciénaga flow into what became a creek-like incision. This resulted from an effort to avoid flooding two later abandoned agriculture fields, situated down-channel left or on viewer's right. Before this ciénaga was damaged, it likely migrated through the entire valley width shown here. Photo: Cinda Cole (2007).

The Importance of Ciénagas

The importance of ciénagas cannot be overstated. Their frequent association with springs endows them with a considerable degree of permanence and endemism, thereby providing critical habitat for an abundance of distinctive and rare plant and animal species (Hendrickson and Minckley 1985; Sivinski and Tonne 2011). Wetlands in the Southwest occupy less than 2% of the land area but have an enormous impact on the region (Webb et al. 2007). Before the arrival of Europeans, these boggy wetlands often extended from one canyon wall to the other, wetting valley bottoms that were broader than a football field is long.

Wetlands are critical habitat for many at-risk species. Approximately 80% of all of New Mexico's sensitive vertebrate species that are listed as threatened or endangered depend on riparian or aquatic habitat at some time during their life cycle (New Mexico Department of Game and Fish 2000). Of the 1,320 species in the United States listed as either threatened or endangered under the Endangered Species Act, 573 are animal species and nearly half of these live in aquatic environments (McCool 2012).

Beyond its value to endemic, threatened, and endangered species, ciénaga restoration will better support all wildlife; improving habitat in otherwise arid regions will result in desert ciénagas and riparian corridors that are increased in size and consequently hold more water. Though ciénagas have long been overlooked in conservation priority assessments, scientists have argued for increasing the priority of ciénaga conservation because of the typically high endemism and habitat diversity of desert wetlands (Minckley et al. 2013). Ciénaga restoration—installing a wide variety and large number of grade-control structures—slows floods and flows, increases seepage and wicking, broadens wetlands, raises water tables, and thereby enlarges ciénagas and riparian corridors (Minckley et al. 2013).

Over the course of the last decade, the ciénaga restoration project on the Pitchfork Ranch—still less than half complete—has included the installation of more than 200 grade-control structures that have raised the water table nearly 0.3 m (1 ft), have raised the entire watercourse bed more than 0.3 m (1 ft) throughout the ranch's 14.5-km (9-mi) reach of the Burro Cienaga, have correspondingly raised the level of the surface water, have widened and "shallowed" the channel, have captured 27 Mg (30 ton) of sediment, have increased vegetation, and have caused surface water to extend farther down-channel for a longer period of time before water recedes underground. The results of restoration can be seen from the pair of same-location photographs in Figure 4.

Archaeological sites frequently surround ciénagas and contain evidence of Native American land use and fossil remains of prehistoric animals (Hendrickson and Minckley 1985). Researchers are currently analyzing charcoal, pollen, and stable isotopes preserved in ciénaga sediment in order to uncover the development and history of the region (Meyer 1973; Minckley and Brunelle 2007; Minckley et al. 2009; Brunelle et al. 2010). By matching these data with tree-ring and fire data, researchers are bringing the region's history into increasing clarity (Davis et al. 2002).

The implication of disappearing ciénagas in the arid Southwest is even more worrisome when viewed in the context of the availability of the word's potable water. Only 3% of the globe's water supply is freshwater, and of that, 69% is locked up in ice and glaciers and 30% occurs underground, leaving less than 1% of the Earth's freshwater available as surface water (Gleick 1993). Importantly, although typically given little thought, ciénagas are freshwater. The degradation and loss of wetlands is more rapid than that of other ecosystems (Millennium Ecosystem Assessment 2005). In a global context, destruction of the few remaining ciénaga wetlands may seem minuscule, but when ciénagas are viewed as a source of aridland surface water, the losses have enormous

Fig. 4. These photographs were taken from the same location on July 18, 2005, and September 26, 2014. Notice Soldier's Farewell Hill in the background at about 12 km (8 mi) of the Burro Cienaga and the cholla cactus skeleton, lower left. The top photograph was taken after the boulder baffle was installed and coyote willows were planted, down-channel right, mid-picture. Photos: Cinda Cole (2005 and 2014).

importance, especially to the endemic plants and animals that coevolved with and are dependent on these systems.

Ciénagas also provide *ecosystem services* (White 2008; Millennium Ecosystem Assessment 2005). This is an emerging restoration notion in which market value is attributed to a variety of environmental functions provided by landowners for the public good and for which they have historically not been compensated. These services include filtering rain and snowmelt, slowing seasonal flood pulses to reduce stream-channel degradation and slow soil erosion, promoting groundwater recharge, and delivering clean, safe drinking water at a far lower cost than would be required to build infrastructure to replace these habitats and their services. Although underrecognized, when both the marketed and nonmarketed economic benefits of wetlands are included, the total economic value of unconverted wetlands is often greater than that of converted or dewatered wetlands (Millennium Ecosystem Assessment 2005).

A recently touted ecosystem service that further strengthens the importance of ciénagas is the notion of the "carbon sequestering sweet spot" (White 2014). Thousands of years of careless land use has caused the release of nearly 80% of carbon—up to 80 billion tons—from the world's soil into the atmosphere (White 2014). Increasingly, soil researchers note that responsible soil management can recapture most of the misplaced carbon by bringing soil back to health, creating opportunities for plants to capture and convert sunlight into high-energy sugars and break down atmospheric carbon dioxide into oxygen (Ohlson 2014). Wetlands are the world's best ecosystems for capturing and storing carbon in their soils (White 2014). There are few "carbon sinks" in the arid Southwest and we posit that none are superior to rich, dark ciénaga soils.

Ciénagas also have cultural implications. Water serves multiple vital purposes, one of which is often overlooked but lends weight to the merit of restoring ciénagas. Ciénagas play a sacred and functional role in the lives of many Native Americans, as Indigenous People traditionally consider springs to be alive. They were points where creation came to the surface and spilled out, where a hand could reach down and feel life surfacing (Childs 2000).

Aggradation and Degradation of Aridland Ciénagas

We suggest two perspectives for studying the history of aridland ciénagas: (1) their development during the 10,000 years before Anglo-European entry to the Southwest, and (2) the incision and dewatering processes that impacted them after Anglo-European settlement. Both are important, but ciénaga damage and disappearance will be prioritized and discussed first, as these losses are ongoing and require immediate attention. Although scientists studying ciénagas have only recently begun the daunting task of teasing out the natural processes that established them, the explanation for ciénaga deterioration and loss is clear. In less than 200 years, a series of mostly human-caused events joined forces to transform these lands from a depositional environment to an erosional one, severely lowering groundwater tables and resulting in the loss of most ciénaga habitat. What nature painstakingly assembled over a period of some 10,000 years, we brought asunder in less than 200 years (Minckley et al. 2012).

Seven Factors Responsible for Ciénaga Degradation and Disappearance

The causes for ciénaga dewatering in the Southwest are complex. The seven factors below are causal factors driving ciénaga dewatering and the general desertification of the Southwest.

1. Sheep Introduction. The disappearance of ciénagas began with the introduction of livestock by the Spanish. The first documented arrival of livestock in the Southwest was in 1598 with Juan de Oñate and his party of colonists, who introduced sheep. By the late 1700s, sheep were a major regional industry (Dunmire 2013). One of the descriptions on Miera's 1758 map—the earliest of New Mexico—put sheep numbers held by Spanish and Puebloan herders at 115,826 animals (Kessell 1979). By 1865, the count of sheep had more than doubled and the ratio of sheep to cattle ballooned to 37 to 1—4,600,000 sheep to 125,000 cattle (Dunmire 2013). The land could not withstand the grazing pressure of these animals; barren soil, erosion, and arroyo cutting resulted from severe overgrazing (Hendrickson and Minckley 1985).

2. Beaver Eradication. Ciénaga dewatering worsened with the overtrapping of beaver (*Castor canadensis*) in the 1820s–1830s (McNamee 1994). Beaver are capable of building as many as 20 dams per 1.6 km (1 mi) of stream, causing water to course across the landscape, transforming otherwise rushing flows into a series of pools and murky wetlands linked by shallow, multiple-branched channels (Mann 2011). Untold numbers of beaver lodges once dotted desert waterways, forming reservoirs that helped control seasonal flooding, which in turn thwarted erosive processes.

When beaver were trapped out of southwestern rivers, shallow flatland watercourses and adjacent riparian zones created by beaver shifted from complex systems dominated by ponds, multiple channels, ciénagas, marshes, and otherwise wide wetlands plentiful in fish and wildlife into simple, incised, single-thread channels with narrow strips of riparian vegetation (Wild 2011). In a short period of time, beaver were virtually trapped out of southwestern rivers, a second step in converting dynamic and complex stream and river ecosystems into the relatively static and simplified water delivery systems of today (Wild 2011).

3. Agricultural Recontouring and Aquifer Depletion. Many ciénagas also suffered damage when early settlers recontoured the broad ciénaga canyon flats in a misguided attempt to prevent the flooding of their agricultural fields. The Pitchfork Ranch has two of these recontoured and now abandoned fields (Fig. 3). Throughout the Southwest, remnant ditches, dikes, and dams persist today throughout many of the old canyon fields near the few remaining and poorly functioning ciénagas (Minckley et al. 2012). The resulting channelization and concentrated flow have reduced these historic wetlands to a fraction of their original size and inadvertently created deep, high-walled incisions that have progressively worsened—though most farming has long since ceased—and lowered the groundwater table even more, further dewatering formally wetted ciénaga habitat (Fig. 2).

As we have pointed out, not all ciénagas follow the same pattern of degradation and disappearance. For example, with little upland or channel erosion, irrigation-well pumping for cotton farms is almost entirely responsible for the final demise of the huge San Simon Cienega in Hidalgo County, New Mexico. The small ciénagas surrounding Apache Tejo Kennecott Warm and Kennecott Cold Springs near Hurley, New Mexico, were dried up primarily by water wells drilled into them for the copper smelter. The aquifer for the huge Comanche Springs Cienega in west Texas was captured and depleted by the urban wells of the City of Fort Stockton (Sivinski and Tonne 2011; Sivinski, pers. comm. April 2015).

4. The Rise of Cattle Ranching. The damage caused by sheep, the decimation of beaver, conversion of land to agricultural fields, and aquifer depletion was worsened in the 1880s with the overstocking of cattle (Bahre 1991). Channel incision occurred throughout the Southwest due to livestock trails, as well as old wagon roads and "two-track" trails (Zeedyk 2006). Grass cover dominated the landscape through mid-century but, due to ranching, began to disappear by the 1880s, accompanied by the explosion of mesquite and creosote as woody plants outcompeted the once ubiquitous, now overgrazed grasses (Bahre 1991; Dunmire 2013). In 1865 the ratio of sheep to cattle was 37:1, yet within 25 years the ratio had narrowed to less than 2:1—3,492,800 sheep to 1,809,400 cattle (Dunmire 2013). In little more than a century, sheep ranching went from New Mexico's leading industry to one of minor importance (Dunmire 2013). Near the onset of severe overgrazing—including congestion in wetlands—the well-documented cycle of arroyo cutting accelerated the destruction of ciénagas (Hendrickson and Minckley 1985).

5. Drought. Drought—the only natural or non-legacy cause of ciénaga dewatering—has always been central to the Southwest, but severe weather and drought exacerbated the problems of the beaverless, recontoured, and overstocked landscape and the severely degraded grasslands and wetlands (Hendrickson and Minckley 1985).

6. Fire Suppression. The elimination of fire from the Southwest also caused significant habitat changes to ciénagas. Prior to European arrival, burning was frequent enough to exclude most woody plants, while promoting the growth of grass species (Davis et al. 2002). This frequent fire regime was a well-established, natural intervention that allowed grasses to outcompete woody plants. The near absence of fire following European arrival transformed pre-European grasslands to woodlands, facilitating erosion and contributing to ciénaga losses (Davis et al. 2002).

7. Human-Caused Climate Change. Although climate change has not been noted as a significant source of damage to ciénagas, it will in the future, as there is now irrefutable scientific consensus that the human global systems of commerce and energy are degrading the natural global systems that support life on the planet, posing an enormous long-term threat to life as we know it (Klein 2014). Climate change may well turn out to be the worst of these seven ills, as human activities have already changed the climate of the Southwest.

Scholars are offering increasingly dire projections (Saunders et al. 2008). Megadroughts are predicted for the Central Plains and the Southwest by the end of the 21st century, and the Southwest could experience the driest conditions in a millennium (Yeager 2015).

Climate change is already affecting the American West more than any other part of the United States, outside of Alaska (Saunders et al. 2008). During the last five years, the West has experienced an increase in average temperature, compared to the 20th-century average, that is 70% greater than the world as a whole (Saunders et al. 2008). The average New Mexico summer is 3.4°F warmer now than in 1984. New Mexico summers are predicted to be hotter, dryer, and longer (Houser et al. 2015).

Climate warming is assured and does not bode well for the future status of ciénagas. The borderlands are going to get warmer, and minimum winter and maximum summer temperatures will increase in the Southwest. The severity and duration of drought and intensity of precipitation events will worsen, precipitation will decrease, and snowpack runoff will lessen and occur earlier, all of which will increase stress on ciénagas and wetland systems generally (Brunelle et al. 2010; Zeedyk et al. 2014). The Arctic is warming about twice as fast as the rest of the planet and heat-trapping greenhouse gas concentrations continue to rise, with the global average atmospheric concentration of carbon dioxide now more than 400 parts per million for the first time in human history (Houser et al. 2015). A recent analysis of climate change posits that the 2011 Texas and English heat waves were, respectively, 20 and 60 times more likely than they would have been 50 years earlier, because of climate change.

With climate change dramatically escalating and with the soaring frequency of extreme weather, ciénaga restoration and management will become increasingly difficult. The erosive force of more-intense storm events will increase the rate of degradation of unstable systems and decrease the likelihood and extent of restoration success (Zeedyk et al. 2014).

The forthcoming barrage of heat, droughts, and high-risk weather will occur in a context of a Southwest landscape already severely degraded, depleted of grasses and groundwater, and with ever-deepening incisions. Almost a century ago, Aldo Leopold forewarned us about the importance of restoration: "When the gullying and loss of bottom lands once starts, no system of range control, unaided by artificial works, can possibly check the process" (quoted in Meine and Knight 1999).

Add extreme weather events—more heat, less snow and rain, floods, droughts, and worse storms—on top of these existing conditions and it becomes clear that the task of recapturing stable ciénaga dynamics is a formidable one.

Summary of Benefits and Destructive Causes

The benefits provided by ciénagas to the aridlands of the Southwest are many. Ciénagas not only provide rich habitat for plant and animal life, they were also historically responsible for lateral spreading of flood pulses that wetted large swaths of land. This diffuse broadcasting of water resulted in abundant aboveground vegetation, thereby limiting the erosive potential of floods and protecting softer surface sediments. Broad ciénaga surfaces in floodplains dispersed seasonal flood pulses into sheet flows and prevented channelization. Floodplain ciénagas and grasslands formerly captured large amounts of sediment suspended in sheet flows that for the past 200 years have eroded barren soils and created today's gully-washers, or heavy, fast, and destructive water (Minckley and Brunelle 2007). Rushing water now surges through ever-deepening incisions or arroyos throughout the Southwest. The result is heightened flash-flooding and exaggerated channel discharge that have reduced water tables and further worsened the already severe dewatering of ciénagas (Minckley and Brunelle 2007). The introduction of cattle and sheep, elimination of beaver and fire, agricultural recontouring, and drought have caused irreversible change.

The combination of the above forces had synergistic implications that transformed the entire Southwest, causing desertification that has drastically reduced ciénagas and extent of wetlands (Minckley et al. 2013). Review of the papers addressing ciénagas suggests the dominant land-surface process in the Southwest today is stream scour, which is the opposite of sheet flow, or slow-moving water, a phenomenon that was far more common just 200 years ago (Hendrickson and Minckley 1985). The current status of ciénagas is stark. Since the late 1800s, erosion associated with post-settlement channelization and drawdowns of local water tables have dried up most ciénaga environments to a mere 5% of historic ciénaga habitat (Fig. 5; Minckley and Brunelle 2007).

Fig. 5. Former San Simon Cienega on the Arizona/New Mexico border now dead, beyond any possible recovery despite a determined, long-range government effort, since abandoned. Photo: Cinda Cole (2010).

Ciénagas Developed Slowly over Eons

Unlike the short period of abrupt and rapid destructive forces that destroyed most ciénaga habitat, the mechanisms underlying their development about 11,500 years ago at the beginning of the last ice age were gradual (Minckley et al. 2009). Interwoven, multidisciplinary approaches drawn from botany, geology, geophysics, geography, and other disciplines are allowing the elusive ciénaga history to slowly be revealed. As summarized in Table 1, scientists are teasing out this history by investigating the record of soil buildup via sediment analysis of cores drawn from ciénagas. These cores contain stable sedimentary isotopes, pollen, microscopic charcoal or fire remnants, and elemental fractions of organic materials that allow identification of the sources of the material buried within the sediments.

There are several summarizing conclusions that can be drawn from the chronology presented in Table 1: (1) Ciénagas developed gradually over 10 millennia, with only occasional spikes in their aggradation between 6000 BP (before present) and the arrival of Europeans in the Southwest; (2) European settlers immediately reduced fire incidence and put an end to tree or other woody-plant burning and started the trend in which trees outcompete grass, still ongoing today; and (3) weather factors, especially El Niño and La Niña events, are the primary drivers for fire occurrence and frequency in borderland desert grassland systems and are key to understanding the severe weather variability unique to the

Table 1. **Timeline of Ciénaga Development. The time period Before the Present is abbreviated with "BP," the Common Era often referred to as AD, is noted as "CE."**

21,000 BP	The period of the last glacial maximum. Ice sheets throughout the globe were at their maximum on Earth, glaciers were at their thickest, and sea levels at their lowest. The American deserts were forested, with the landscape punctuated by large pluvial lakes and flowing rivers (Minckley et al. 2009).
11,500 BP	Pleistocene Epoch ended and Holocene Epoch began. Stream flows remained strong, capable of moving rocks and cobbles, precluding establishment of most ciénagas, save those few along more protected reaches (Minckley et al. 2009).
8000 BP	To date, the oldest continuous evidence of ciénaga materials that allows inferences as to when and how ciénagas developed; water flows remained robust and thus prevented the wholesale establishment of ciénagas. This was a time when winter precipitation was minimal and fire was rare (Brunelle et al. 2010). However, there is evidence of ciénaga development in the International Four Corners Region into the last ice age (Minckley et al. 2012).
7200 BP	Initial stabilization of ciénagas as surface flows slowed, allowing formation of wetlands. Although there have been periods of rapid ciénaga development, during most of the past 7,000 years ciénagas have been slowly aggrading (Minckley and Brunelle 2007).
6000 BP	Onset of El Niño/La Niña–Southern Oscillation, with recurring, alternating, quasiperiodic warm and cool climate patterns that occur across the tropical Pacific Ocean and account for much of the fire variability in the Southwest (Brunelle et al. 2010).
5300 BP	Before this period, woody plants dominated the uplands, with fire-episode frequency below one fire every 200 years and even more infrequent when winter precipitation was low. The transition to grasslands began at approximately this time; after this period, fire frequency increased to 1.3 fires every 100 years (Brunelle et al. 2010).
7200–4100 BP	Fine-grain sediment increased, suggesting permanent and prolonged annual wetting. Stable ciénagas went through at least three steady states after initial stabilization: 6300–6000 BP, 4700–4000 BP, and 1600–750 BP.
4500 BP	Due to heavy moisture, a period of river system down-cutting in the Southwest. Fire frequency increased to one fire every 48 years (Brunelle et al. 2010).
4100–2400 BP	1,700-year dry interval period where ciénaga water permanence drastically lessened and fire frequency decreased to only one fire every 100 years (Brunelle et al. 2010).
4100–1300 BP	With the Southwest dominated by grasses, this period is similar to the present day. Ciénagas were stable, with the transitional shift from arid habitat to wetter conditions trending toward more aquatic states, conditions that persisted until European settlement (Brunelle et al. 2010).
3400 BP	Earliest presence of human activity is demonstrated by the presence of corn (*Zea*) pollen at Animas Creek Cienaga in New Mexico. Corn pollen has been found in various sediment cores extracted from ciénagas throughout the region, establishing Native Americans' use of ciénagas and their surroundings (Brunelle et al. 2010).

1300–750 BP	Stability in upland vegetation and ciénaga surfaces, water ponding and stagnation of the water likely occurring (Minckley et al. 2009). Sedges and cattails dominated and fire frequency increased to one every 38 years (Brunelle et al. 2010).
1680 CE	Pueblo Revolt expelled Spanish for 12 years until the reconquest in 1692 (Dunmire 2013).
1700s CE	Dramatic decline of charcoal corresponds with the appearance of pollen from a European plant, filaree (*Erodium cicutarium*). Sediment cores are dated to about 1795, which corresponds with establishment of Camp Grant in 1860, 200 years after Spanish recolonization in 1692. Coring shows frequent burning of some ciénagas before the arrival of Europeans. Six ciénagas record an increase in dung fungus (*Sporormiella*) spores common among grazing animals, in response to the introduction of livestock. This change in fire history is linked to human activity by the pre-settlement presence of the pollen of weeds and corn (*Zea*) in the ciénagas (Davis et al. 2002).
1800 CE	Before 1800, fire frequency had increased, on average, to one fire every decade, but abruptly decreased with the displacement of native agriculture by Euro-American settlement, triggering accelerated post-settlement transformation of wetland vegetation toward woody species (Brunelle et al. 2010).

Southwest. This extreme climatic variability overshadows all other factors influencing fire, vegetation, and ciénaga conditions (Brunelle et al. 2010).

The 1985 Call for Scientific Study of Ciénagas

The importance of ciénagas, the extent of their disappearance, and their ongoing damage were recognized only some 30 years ago by ichthyologists Hendrickson and Minckley (1985). They studied ciénagas in southeast Arizona and for the first time registered them on the academic radar. As a result of their summons for further study, current research has focused on diverse aspects of ciénagas, including their history; their vegetation composition; how and when they developed; the extent and causes of ciénaga losses; the impacts of climate change; and the means and potential for their restoration, conservation, and management (Minckley et al. 2012). Scientists are rapidly gaining an understanding of these unique wetlands of the arid Southwest.

Microscopic charcoal from six Sonoran Desert ciénagas in Arizona and Sonora, Mexico, documents a marked expansion of wetland taxa, particularly woody plants, about 200 years ago when Europeans arrived (Davis et al. 2002). These studies (Table 2) chronicle a series of abrupt changes in fire, vegetation, and sediment content during the transition from the periods before and after arrival of the Spanish, and summarize findings consistent with these changes (Davis et al. 2002; Minckley et al. 2009).

Recent studies have expanded upon Hendrickson and Minckley's (1985) work and convincingly demonstrated the increasing peril facing this unique aridland water (Minckley and Brunelle 2007; Minckley et al. 2009; Minckley et al. 2013). Spring ecosystems are among the most threatened ecosystems on Earth (Stevens and Meretsky 2008).

Table 2. Absence of fire in the Southwest upon arrival of Anglo-Europeans. Source: Davis et al. (2002), unless otherwise noted.

- Historic documents indicate frequent burning of southern Arizona vegetation by indigenous peoples.
- The historic reduction of fire frequency is a general conclusion of most tree-ring studies of fire frequency in the region.
- Before the turn of the century, desert wetlands were described as boggy, open environments with riparian gallery forests situated above the waterlogged soils of the valley bottoms (Minckley et al. 2009).
- The presence of charred seeds and fruits of wetland plants in pre-arrival sediment establishes burning of ciénagas.
- Before this transition, burning was frequent enough to exclude most woody plants.
- Prehistoric agricultural utilization of ciénagas is demonstrated by the presence of corn (*Zea*) and pre-Columbian weeds. The change in fire history is linked to human activity by the prehistoric presence of pollen of weeds and corn in the ciénagas.
- Borderland ciénagas show a marked expansion of the pollen of wetland taxa during the post-arrival period and these expansions follow or are accompanied by decreased charcoal abundance.
- The six Sonoran Desert sites studied by Davis appear to record increases in charcoal percentages up to the time of the abrupt fire decline. This fall-off in sediment charcoal indicates a dramatic decrease in fire frequency in the period after European arrival.
- Reduced fire frequency caused the historic transformation of wetland vegetation in the Sonoran Desert to woody plants.

The Extent of Ciénagas

Partial ciénaga inventories presented in scientific literature offer differing definitions and terms to describe and categorize ciénagas. Some writers list only functioning ciénagas (Sivinski and Tonne 2011), while others include a far broader range of ciénaga conditions (Housman 2010). Other researchers limit their treatment of ciénagas to certain regions of the Southwest, excluding those outside their geographic range of interest (Hendrickson and Minckley 1985; Minckley et al. 2013). Additionally, there are researchers who include wetlands above a certain altitude (Minckley et al. 2013), while others exclude them, rather defining them as "high mountain meadows" (Sivinski and Tonne 2011). These differences typically reflect the scope or purpose of the research, although these differences have muddled the understanding of ciénagas as recent research has heightened appreciation of their importance. Because of ciénaga scholarship's relative newness, varying research purposes, and differing criteria used to describe ciénagas, it is difficult to reconcile available data in order to answer questions about their numbers, extent, and condition.

Prior to European settlement, there were likely hundreds of overlooked or forgotten ciénagas—unnoticed or unnamed—with the result that, at elevations below 2,133 m (7,000 ft), only 155 identified ciénagas are known to currently exist in the entire International Four Corners Region of the Southwest—Arizona, Sonora, New Mexico, and Chihuahua—along with several outliers in west Texas (Fig. 6). Tom Minckley (pers. comm. 2012) speculates that there may be well over 200 ciénagas, not the 155 that are listed (Fig. 6; Appendix B). Dean Hendrickson (pers. comm. 2014) suggests that there are hundreds if not thousands of ciénagas undocumented across the West. As awareness of their importance increases, so will the number of identified ciénagas. There are also named ciénagas that can no longer be located and an unknown number of scattered ciénagas existing on private land but held secret because landowners fear that detection will adversely affect their property rights.

All ciénagas known to us are described in Appendix B and mapped in Figure 6. Of the 155 we have identified, 87 (56%) are either dead or so severely compromised that there is no prospect for their restoration. We believe 40 (26%) remain functional and 28 (12%) are restorable. Because this paper is intended as a working inventory of known ciénegas, we have included in Appendix B seven additional ciénaga-like waters found above 2,100 m (7,000 ft), but these are outside the scope of this paper and are included for reference only. See Appendix C for additional water sources that can be found along and nearby historic travel routes, many of which were, at one time, likely ciénagas.

It is critical to keep in mind that a simple numerical count of ciénaga losses seriously understates the extent of ciénaga habitat loss. Most ciénagas that still have perennial water are severely incised and retain but a thin slice of their historic width (Figs. 1–3). Hendrickson and Minckley (1985) estimated habitat loss of ciénagas to be upwards of 95%, a figure commonly reported in the literature (Makings 2013). In the editor's introductory note to Hendrickson and Minckley (1985), Crosswhite stated that ciénaga locations were among the most mistreated sites on Earth. As an illustration of this point, Figure 3 makes clear that the reach of the Burro Cienaga on the Pitchfork Ranch is less than 5% the width that existed before settlers recontoured the valley.

A Proposed Classification System for Ciénagas

Proposed here is a ciénaga classification system based on current function, stability, and restorability. This is a meaningful way to identify, evaluate, and prioritize those ciénagas

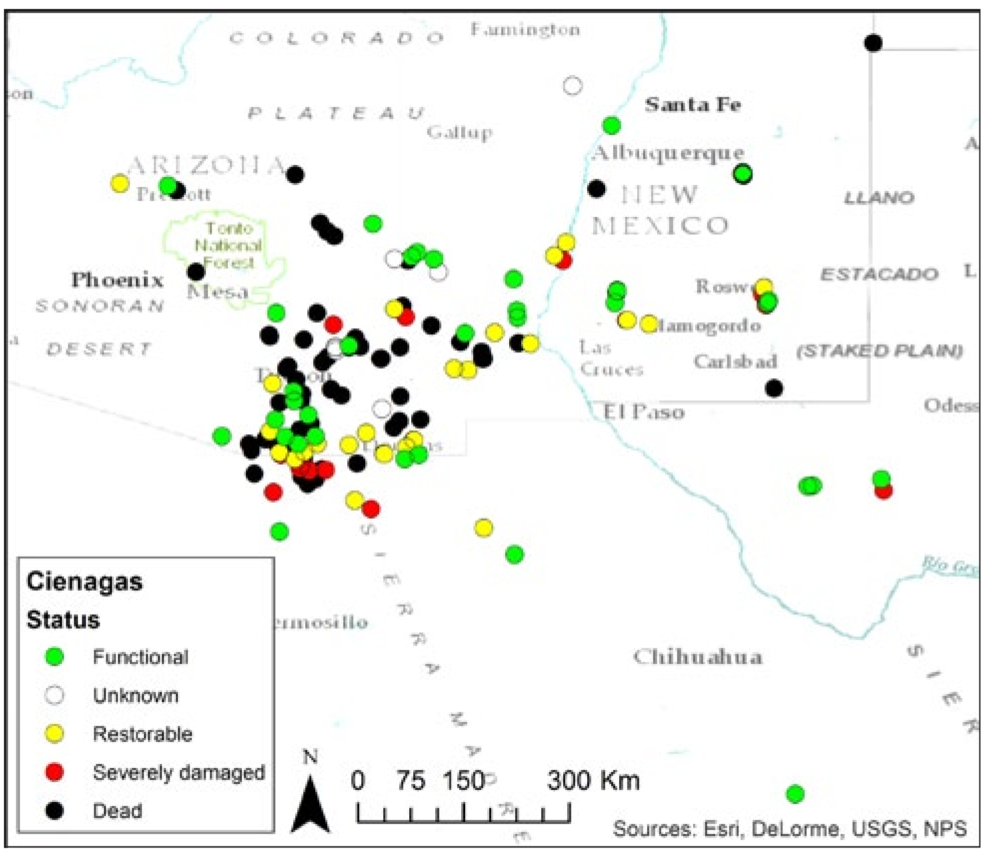

Fig. 6. Ciénaga locations in the International Four Corners Region. Map: Ben Labay, Ichthyology Collection, Integrative Biology, University of Texas, Austin (2015).

that can be restored and where agencies and landowners can best invest limited capital. The four categories presented take into account what was; what is; and what could be if ciénagas were recognized, prioritized, and restored.

1. ***Functioning Ciénagas.*** These are ciénagas whose structure and function are essentially unimpaired: not seriously incised, often broad and marshy, functioning much as they did before Spanish and Anglo settlement. However, most of these are markedly reduced in size. A mere 26% (*N* = 40 total) of ciénagas listed in Appendix B remain intact, and their rarity mandates high-priority management and preservation (Figs. 7 and 8).

Fig. 7. Cloverdale Cienega, Bootheel region of southwest New Mexico. This is what an essentially undamaged ciénaga looks like. Photo: Thomas A. Minckley (2008).

Fig. 8. Cieneguita, Las Cienegas, north of Sonoita, Arizona. With almost no incising, this is a smaller, functioning ciénaga. Photo: Karla Sartor (2012).

2. ***Restorable Ciénagas.*** These ciénagas still have perennial water and abundant ciénaga flora in their marshy reaches, but in other stretches are dry or function like creeks. They are deteriorating toward a drained state but remain in a semihealthy condition and are ideal candidates for restoration. These ciénagas have potential to be restored to fully functioning status. They make up about 18% (*N* = 28) of all ciénagas documented in Appendix B (Figures 1–3).

3. ***Severely Damaged Ciénagas.*** These are ephemeral, periodically wetted by rains. They have questionable restoration potential and make up just over 12% (*N* = 18) of ciénagas listed in Appendix B.

4. ***Dead Ciénagas.*** At least 44% (*N* = 69) of ciénagas included in Appendix B are dead, their water tables so severely depleted that restoration, given water tables and today's techniques and economics, is not feasible (Fig. 4).

Were there a greater number of ciénagas in the Southwest before Spanish sheepherders, American trappers, and the other causes of the Southwest's dewatering? Definitely. Were there hundreds more? Probably, but there are some who disagree and the answer will likely never be known. At one time, there were springs along the travel routes noted in Appendix C. Most of them no longer exist, and of those, there surely were some that supported unnoticed or undocumented ciénagas. Are there other existing ciénagas not on this list? Certainly, we know of some now. Will other ciénagas be added to this list? Surely; we just added one. Are there more than two dozen restorable ciénagas? After our experience in the ongoing task of restoring the reach of the Burro Cienaga on the Pitchfork Ranch, we suspect not. Yet there are those who see this differently too. Is there uncertainty and more to learn about ciénagas? Yes, for sure. Is there any habitat restoration in the Southwest more important? We think not, and we doubt that many people, once fully informed, will disagree.

A Proposal for Restoration and Preservation

Desert wetlands have long been overlooked in conservation-priority assessments and yet have exceptional value for avian diversity, as historic riparian sites in the Southwest lessen in number and more species of migrating birds use isolated ciénegas (Minckley et al. 2013). The conservation potential for ciénagas in arid and semi-arid ecosystems is incredibly high, considering the wealth of ecosystem services these environments provide when functioning properly. Their conservation value will increase under the conditions expected with global climate change.

Given the challenges of how to best spend limited conservation dollars and resources, conservation and restoration of extant ciénages may prove to yield the greatest net benefit to counter current endangerment (Minckley et al. 2013).

As the inventory of ciénagas in Appendix B shows, few remain and many are damaged beyond repair. We note location by state and condition in Table 3. These numbers demonstrate that 87 (56%) of all aridland ciénagas known to exist are beyond repair and only 68 (44%) are suitable for preservation and restoration. Yet even these disheartening numbers are starkly deceptive, because 95% of all ciénaga habitats have been lost. The importance of ciénagas warrants a far more concerted restoration and preservation undertaking than the current unfocused effort.

We propose that the New Mexico Department of Game and Fish, the Arizona Game and Fish Department, and corresponding entities in the Mexican states of Sonora and Chihuahua collaborate to create the position of Ciénaga Coordinator so that the four states can work together to develop a program of restoration priorities and outreach to owners of ciénagas, both public and private, and thus begin a formalized region-wide process of ensuring the persistence of ciénagas in the International Four Corners Region. These coordinators' charge should entail not only identification and prioritization of ciénaga restoration, but extend to:

- Collaborating with owners
- Identifying restoration and funding sources
- Providing assistance in seeking funds
- Arranging or recommending restoration personnel
- Overseeing restoration activities when requested
- Periodically conducting site visits with the goal of helping owners ensure their ciénagas' long-range care
- Exploring the option of conserving ciénagas with protective fencing
- Recommending, when appropriate, optional conservation easements and other preservation measures

Table 3. Known ciénagas occurring at elevations below 2,133 m (7,000 ft) by state, functional condition, proportion of total, and total percent. Fewer than half (44%) of known ciénagas are functional and/or restorable, while 56% have no potential for restoration or are dead.

Total Number	Condition (total N by category)	Condition as percent of total
67 (Arizona, USA)	**Functional** (39)	25%
60 (New Mexico, USA)	**Restorable** (29)	19%
4 (Texas, USA)	**Severely Damaged** (18)	12%
1 (Coahuila, MX)	**Dead** (69)	44%
20 (Sonora, MX)		
3 (Chihuahua, MX)		
155 (Total)	155	100%

Depending on the extent of damage, the depth of incision, and related factors, the restoration process can be costly and extend over many years, emphasizing the need for Ciénaga Coordinators. Many private landowners do not fully appreciate the importance of ciénagas and few can afford the cost of what, for us, projects to be a more than two-decade process. Except in the most exceptional cases, public funding is necessary.

In view of the ecosystem services that ciénagas provide and their importance in providing habitat for endangered, at-risk species and wildlife in general, various scholars have already stated that no habitats in the Southwest are more important to restore (Minckley et al. 2012). The carbon sequestration potential of wetlands adds yet another benefit of prioritizing ciénaga restoration (White 2014; Ohlson 2014). The highest rate of return, the most benefit per dollar of public funds invested in ciénaga restoration, underscores this call for Ciénaga Coordinators.

Zeedyk and Clothier (2009) have detailed an evolving template for restoring incised channels in the arid Southwest and acknowledged that additional practices would likely be developed. Indeed, after a decade of restoring the portion of the Burro Cienaga on the Pitchfork Ranch, we have happened upon several other types of grade-control structures, incorporated in Zeedyk and colleagues (2014). A concerted focus on these unique desert habitats should lead to an increased emphasis on restoration and preservation strategies.

The Ethical Imperative for Restoration

Rapid degradation of the landscape across the nation was Aldo Leopold's abiding concern and brought him to confront the universality of challenges facing the protection of important habitat: "The government cannot buy 'everywhere' . . . The private landowner *must* enter the picture . . . The basic problem is *to induce the private landowner to conserve his own land*, and no conceivable millions or billions for public land purchase can alter that fact, nor the fact that so far he hasn't done it" (quoted in Meine and Knight 1999, 162; emphasis in original). Although these endangered habitats have suffered rapid change and a staggering number of losses, the few remaining ciénagas are salvageable, beneficial, and even profitable if restored, but private landowner participation is essential.

Widespread spontaneous recovery of ciénagas is unlikely without concerted restoration efforts. Ciénagas will self-heal only in small areas where local geomorphic structure is particularly favorable to wetland development (Heffernan 2008). Once established, cienéga vegetation appears highly resistant to removal by seasonal flooding, has a stabilizing effect on the streambed, and thus becomes a sink for sediment trapping and water retention (Minckley et al. 2012). The dramatic change evident in the photographs in Figure 4 demonstrates how quickly ciénagas and riparian habitat respond to restoration. Carbon sinks are wetlands that are highly efficient in capturing carbon, and, although recent publications addressing this question of carbon sequestration neglect to mention ciénagas, we suggest that ciénagas serve as ideal carbon sinks, of which there are so few in the Southwest (Schwartz 2013; White 2014; Ohlson 2014).

Widescale recovery of ciénagas will require a significant shift in awareness among the general public, rethinking by bureaucrats, and a much-needed broadening of the current political ethic to emphasize land, water, and habitat restoration in order to return these aridland waters to their natural state.

Conclusion

Everyone—politicians, agency personnel, scholars, and land managers and owners—is interested in a return on investment. The persistent question is where to best spend limited funds. In Arizona, as of 2012, there were 82 plants or animals considered to be endangered, threatened, or proposed for listing under the federal Endangered Species Act. Of these, 16 are directly associated with ciénagas (Minckley et al. 2013). Aridland springs and ciénagas provide vastly disproportionate benefits to regional ecology, evolutionary processes, and sociocultural economics in relation to their size and number (Stevens and Meretsky 2008). We know from our own experience at the Pitchfork Ranch that there are only limited funds available for ciénaga restoration and habitat improvement. If funders and restoration practitioners expect to meaningfully help at-risk plants and animals, and contend with climate change, investing in ciénaga restoration can help.

More than all other habitat types, ciénagas have the potential to represent a great success story in conservation, given that the degradation of these systems is relatively recent and that ciénagas have remarkable resilience once disturbance pressures are removed (Minckley et al. 2012; Minckley et al. 2013). Despite the troubling number and scope of losses and severe damage to the few ciénagas that remain, there are still a good number that have long persisted and these arguably represent the most important resource for the maintenance and preservation of regional biodiversity.

A fundamental tenet of citizenship in the West is to translate Leopold's Land Ethic into reality. There are few opportunities with more potential and greater rewards than the restoration of the remaining ciénagas in the International Four Corners Region. The creation of Ciénaga Coordinators and adoption of a classification system based on their present condition and potential for restoration will help determine which of the remaining ciénagas are within reach of being turned in the direction of their presettlement condition.

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Appendix A. *Ciénaga* Spelling and Punctuation

The *Real Academia Española* has this to say about spelling: The term *cienaga* is derived from Latin *caenĭca, caenum, cieno*; and *ciénaga* is derived from the single word *ciénega*. One theory for the word *ciénaga* is that it derives from the expression *cién aguas*, meaning “a hundred fountains,” “a hundred springs,” or “100 waters” (Hendrickson and Minckley 1985), but, linguistically, the term has nothing to do with either water or hundred. Although the origin of *ciénega* and its variant *ciénaga* is not a simple one, the root is “silt,” which is the meaning of *cieno*. The origin of what can only be considered a colloquial definition—100 waters—is unknown to us, but it is a sensible definition and explanation for spelling *ciénaga* the less common way in the American Southwest. Other enclaves in the Spanish-speaking world (e.g., Colombia) utilize the word in the formal names of many swamps and bogs, and the second-*e* spelling is rare. But spelling *ciénaga* with *a* is less common elsewhere in the Spanish-speaking world.

Julyan (1996) notes that although the *e* spelling had been earlier criticized, many early Spanish explorers and settlers came from Estremadura, Spain, where *ciénega* was properly spelled with a second *e*. Pearce (1965) lists 14 New Mexico examples of *ciénaga* usage—land grants, towns, and water features—and they are all spelled with an *a* and no accent mark over the first *e*. Pearce’s book preceded Julyan’s by 25 years and uniformly uses the *a* spelling, making no mention of spelling *cienega* with a second *e*.

A close examination of these books makes apparent that Julyan used numerous examples from Pearce and substituted the second *e* for *a* without explanation. Two examples are Pearce’s entries for *Cienaga (Otero)* and *Cienaga (Catron)* (p. 35). Pearce spells the ciénagas in Otero and Catron counties with the *a* yet Julyan (p. 84), without comment, substitutes an *e*. The thinking behind the Pearce/Julyan substitution is unknown, and it is also unclear when and why the *e* spelling as represented by Julyan as “general” became so commonly accepted in the Southwest.One explanation for the more common *e* spelling today is that when Hendrickson and Minckley (1985) first suffused the term *ciénaga* with the biological significance unique to the groundwater-fed aridland ciénagas of the American Southwest, they chose the *e* spelling, and it has persisted in the scientific literature.

Neither spelling is corrupted, although the spelling *cienega*, using the second *e* and no accent, has indeed become common in the United States in scientific, if not popular, usage. The spelling with a second *e* is common on many, but not all, contemporary maps. The colloquial explanation—linguistically incorrect—of “cien-aguas” or “100-waters,” with *agua* containing *a* rather than an *e*, does lend a commonsense suggestion for the less common spelling.

The accent mark over the first (or only) *e* is proper, although often omitted.

Appendix B. Working Ciénaga Inventory

In this appendix, we present a list of known ciénegas located in the International Four Corners Region (Arizona, New Mexico, Sonora, and Chihuahua) and a very few outliers in neighboring states. Our reasoning for labeling this list a “Working Ciénaga Inventory” is because ciénaga numbers may forever remain uncertain, any inventory will likely be incomplete, and additions are inevitable.

Those working with these unique aridland water features understand that there are other ciénagas neither noticed nor named and no longer wet, others that are known but in the hands of private owners who prefer to remain off the radar, still others that are mentioned in older reports and overlooked studies, and even more than a few not yet discovered, often known to locals but of little interest. Readers are encouraged to build on this initial effort to identify all known ciénagas. If you learn of an unlisted ciénaga, or are able to identify elevation, latitude/longitude and present status for any listed cienaga in this inventory where information is lacking, please notify us:

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Confusion also surrounds the application of the word *ciénaga* to an entire watercourse, such as the Burro Cienaga, where an 8.4 km (5 mi) reach of the 76.60 km (47.6 mi) Burro Cienaga watercourse was likely never authentic ciénaga. Yet there is a 2.27 ha (5.6 ac) archaeological site adjacent to the Burro Cienaga on the southern portion of the Pitchfork Ranch that was occupied by the Mimbres people over a 400-year period between 700 CE and 1100 CE, suggesting the presence of perennial water. We also found 11,000-year-old Archaic points adjacent to the Burro Cienaga on the north portion of the ranch, making the history of the watercourse rich, but difficult to uncover.

Further confusion surrounds application of the term to former ciénagas that are now desiccated (dewatered), non-living, or "dead." We continue to apply the term when referring to dead ciénagas because inclusion of all ciénagas sheds light on the fact that their numbers were already limited even before the arrival of Europeans and are steadily decreasing today. In addition to springs that may at one time have supported ciénaga habitat, there have been several dozen more named ciénagas (some are excluded here as "high mountain meadows") that do not appear on lists presented in various ciénaga papers. Of course, there are even more ciénagas that have passed into oblivion as groundwater levels have dropped, as well as those that were unnoticed, unnamed, and never documented.

Next, consideration must be given to the upper range of "elevation" when defining a ciénaga. One of the earliest ciénaga elevation ranges applied the term to mid-elevation (1,000–2,000 m; 3,281–6,566 ft) wetlands characterized by "permanently saturated, highly organic, anaerobic soils" (Hendrickson and Minkley 1985). Other studies have extended the elevation to 2,133 m (7,000 ft) (Sivinski and Tonne 2011). Still others have applied the term to spring-fed habitats over 3,048 m (10,000 ft) (Minckley et al. 2012). However, we feel it is best to refer to spring-fed waters at high elevations as "wet mountain meadows" rather than as ciénagas, to avoid diluting the core attributes of ciénagas: often spring-fed, marshy aridland habitat, occurring at elevations below 2,133 m (7,000 ft).

There are also those who understand an earlier, everyday use of the term *ciénaga* that simply means a "wet spot"; permanent water was not necessarily implied by use of the term. While such usage may have enjoyed currency, those "intermittent" water features should not be thought of as ciénagas. Occasional waters are not included here, but rather the well-accepted and narrower definition that considers perennial water as the appropriate criterion and is in keeping with the current, universally accepted use of the term. Authentic ciénaga plants—sedges, rushes, and reeds—will not persist in the absence of perennial water. Water features such as (1) springs without ciénaga plants, (2) *sumideros* (masked sinkholes), (3) high mountain meadows, and (4) "wet spots" are not true ciénagas and are excluded from this working inventory.

There is an assortment of diverse usages or styles for the word *ciénaga* found on various maps. For example, the Burro Cienega is spelled with a second *e* on the 1884 Powell and Kingman map, but with an *a* on the USDI Geological Survey Werney Hill Quadrangle (Geological Survey, 1963) and various other maps, including modern computer-based mapping systems such as the current DeLorme (2006) map. In keeping with the diverse naming of early Southwest water features, the spring or *ojo* along the Burro Cienaga was initially named *Ojo de Inez* by John Russell in 1851 (Bartlett 1965). It is noted as such on Lieut. Wheeler's 1873 expedition map (Eidenbach 2012) and labeled *Ojo de la Inez* on the Captain Allen Anderson *1864 Map of the Military Department of New Mexico* (Eidenbach 2012), yet the 1884 Powell and Kingman map (Powell & Kingman 1884), uses *Burro Ciénega Springs* with an *s,* implying multiple springs as noted initially by Bartlett when he was conducting the post–Mexican War boundary survey. More recent and all current maps refer to the now-singular spring as Cienaga Spring.

The single most uncertain aspect of ciénagas is their numbers. Estimates vary, but seldom exceed 200. The list presented here is thought to be the most comprehensive published inventory to date and identifies only 155 ciénagas. After examining older maps and realizing what a large number of springs (*ojos*) are no longer wet, knowing the number of today's springs that support ciénagas, and knowing that most ciénagas are associated with springs, it seems likely that there were hundreds more ciénagas in the past that were never documented.

The number or percentages of ciénagas can be deceptive. There were likely ciénagas associated with springs noted in Appendix C that are excluded from these numbers, and others that were simply unnoticed or already dewatered when the maps were made. Most importantly, the size of those remaining ciénagas is greatly reduced, as they are typically severely incised and present more "creek-like" than marsh-like habitat. There is a critical difference between the remaining *numbers* of ciénagas and the remaining *acreage* of those ciénagas that are still functional or restorable. While 46% of ciénaga numbers may remain wet, over 95% of historic ciénaga acreage is dry. The combined percentages below indicate that 87 ciénagas (55%) are dead or so severely damaged as to be beyond repair, leaving only 127 ciénagas (46%) either functioning or restorable.

1. ***Functioning Ciénagas.* (F)** These are ciénagas whose structure and function are essentially unimpaired: not seriously incised, broad and marshy, with ciénaga vegetation, functioning much as they did before European contact. These ciénagas remain intact and their rarity mandates high-priority management and preservation.
2. ***Restorable Ciénagas.* (R)** These ciénagas still have perennial water and abundant ciénaga plants in their marshy reaches but in other stretches are dry or function more like creeks. They are deteriorating toward a drained state but remain in a semi-healthy condition and are ideal candidates for restoration. These ciénagas have the potential to be restored to functioning ciénagas.
3. ***Severely Damaged Ciénagas.* (S)** These are ephemeral, periodically wetted by rains, with no ciénaga vegetation. We believe they have little restoration potential.
4. ***Dead Ciénagas.* (D)** This is the largest category. Dead ciénagas have water tables so severely depleted that restoration, given current water tables and today's techniques and economics, is not feasible.

The known ciénagas inventoried here have been identified from the named sources, along with the year we understand the ciénaga first appeared on a written list (without regard to a map) or was brought to our attention. In some instances, data are lacking and it is our hope that the reader will contact us with additional information to compile a more thorough working inventory. It must be noted that in many cases these data have not been ground-truthed. We have relied upon aerial and satellite data to verify the current, or most recent, condition of a given ciénaga, as well as the current location of some ciénegas.

Following the name of each ciénaga, we give the state in which it occurs as follows: AZ = Arizona, USA; CH = Chihuahua, Mexico; NM = New Mexico, USA; SO = Sonora, Mexico; TX = Texas, USA; CO = Coahuila, Mexico. Latitude and longitude follow the ciénaga name for ease of pasting into the Search bar on Google Earth (datum WGS84). Note that some coordinates were collected in an unknown datum so that locations must be considered accurate, but not precise.

These data are also being made available online in an interactive open format for comments and other contributions. Anyone interested in contributing to the correction, evolution, and general improvement and growth of this database, or in using these data for their own research, can do so by going to the permanent archive of this paper at http://hdl.handle.net/2152/30285 and following the link to an interactive site where the data can be mapped, and comments and new records submitted. This site is maintained and moderated by Dean Hendrickson (University of Texas) and Tom Minckley (University of Wyoming).

1. Agua Caliente Ciénaga (also known as: Pantano). Minckley et al. (2012). Mexico, Sonora, Nacozari de García municipio. Aquatic ecoregion (river basin)—Sonora. Coordinates: 30.64062 -109.4248; 934 m (3,065 ft) elevation. Appears to be a living ciénaga. A very rare plant has been found here: Arizona eryngo (*Eryngium sparganophyllum*). **S**
2. Alamosa Springs Ciénega (also known as: Ojo Caliente). Sivinski and Tonne (2011). United States, New Mexico, Socorro County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.57258 -107.60042; 1,893 m (6,210 ft) elevation. Located in the southwest corner of Socorro County, NM, 24.1 km northwest of Monticello, this ciénega is a complex of springs, seeps, and spring runs, some warm. These springs are at the heart of the Warm Springs Apache Tribe, where Apache warrior and seer Geronimo was captured for a short time in 1877 before he escaped. This ciénaga has a population of the endangeredChiricahua leopard frog (*Rana chiricahuensis*) and is the only known habitat for the endangered Alamosa springtail (*Tryonsia alamosea*). **F**
3. Animas Ciénaga. Housman (2010) and Minckley and Brunelle (2007). United States, New Mexico, Hidalgo County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.782571 -108.790884; 1,421 m (4,662 ft) elevation. Southeast of Rodeo, Hidalgo County, NM, this point is now a dry part of Animas Creek south of the town of Animas that once was, but no longer is, a ciénaga. **D**
4. Animas Ciénega. Minckley et al. (2012). United States, New Mexico, Hidalgo County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.527000 -108.884; 1,554 m (5,100 ft) elevation. This former ciénaga was located between the Guadalupe Mountains and Animas Mountains in Hidalgo County, NM. This was the Clanton Canyon arm of the Animas Ciénaga, now almost entirely converted to impoundments and riparian woodland and no longer a functional ciénaga. **D**
5. Animas Creek Ciénaga. Minckley et al. (2012). United States, New Mexico, Hidalgo County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.528000 -108.873; 1,563 m (5,127 ft) elevation. Although severely damaged, this ciénaga has several active surface spring seeps. **R**
6. Apache Tejo Spring. Sivinski, Robert, pers. comm. (2014). United States, New Mexico, Grant County. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 32.6446 -108.0097; 1,678 m (5,504 ft) elevation. This is a dead ciénaga, per Sivinski, dewatered because of the nearby Hurley, NM copper mill. (Sivinski, pers. comm., 2014). **D**
7. Apache Creek Ciénaga. Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Catron County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.8332 -108.6211; 1,957 m (6,422 ft) elevation. Located southwest of Socorro in Catron County, this is a functioning ciénaga. **F**
8. Arivaca Ciénaga. Housman (2010). United States, Arizona, Pima County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.571677 -111.325603; 1,106 m (3,630 ft) elevation. This ciénaga is just south of Arivaca, Pima County, AZ, north of Sonora. This ciénaga is fenced from livestock and with trails through the wet portions, is located to the west of these coordinates. **F**
9. Artesia Ciénaga. Hendrickson and Minckley (1985). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.700000 -109.7; 993 m (3,258 ft) elevation. Located south of Safford, AZ and Swift Trail Junction, there is no ciénaga at this point, only dry barren wetland soils to the north. **D**
10. Babocomari Ranch Ciénaga. Hendrickson, Dean A., pers. comm. (2015). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.631062 -110.451397; 1,390 m (4,557 ft) elevation. Located 7.7 km (4.8 mi) SE of Elgin, a small impoundment with marsh vegetation above a valley of riparian woodland and wet meadows. **F**
11. Babocomari River. Sivinski, Robert, pers. comm. (2014). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.650000 -110.33; 1,245 m (4,085 ft) elevation. East of Huachuca City, a 4-mile stretch of Babocomari used to have more permanent flow with small areas of wet meadow along the banks (Noonan, 2015,http//sciencequest.webplus.

net/Fairbank%20Cienego%20for20web%20Final.pdf). It is presumably intermittent and the ciénaga is now dead. **D**

12. Balmorhea Ciénaga. Hendrickson, Dean A. pers. comm. (2014). United States, Texas, Reeves County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 30.944 -103.7861; 1,012 m (3,320 ft) elevation. Known at one time as Mescalero Springs for the Mescalero Apache who watered their horses there, this deep ciénaga is fed by San Solomon Springs and has been the site of human gatherings for at least 11,000 years. Now part of the Balmorhea State Park, more than 56,781 m^3 (14,999,953 gal) of water flow through a giant swimming pool each day, where it thereafter enters irrigation canals for farmers and travels about 5.6 km (3.5 mi) east to Balmorhea Lake. Concrete encased and commercialized beyond measure, this precious aridland water is far from a natural ciénaga habitat, yet may contain more "live" water than any of the remaining ciénagas. The outlet, before supplying agriculture, passes through a restored ciénega in which the native fish community and invertebrates flourish. **F**
13. Barrel Spring Ciénaga. Sivinski and Tonne (2011). United States, New Mexico, Otero County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.0558 -106.1606; 1,256 m (4,120 ft) elevation. Located west of Alamogordo, NM, Barrel Spring is a small, severely impacted, dredged spillway cut for impoundment. **S**
14. Batte Way Ciénega. Sivinski and Tonne (2011). United States, New Mexico, Otero County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.0076 -105.8709; 1,737 m (5,700 ft) elevation. Located northeast of Alamogordo, this 70 x 30 m ciénaga is severely grazed and damaged by a road cut, although it persists due to being wetted by a small seep spring. **R**
15. Bingham Ciénaga. Sivinski, Robert, pers. comm. (2014). United States, Arizona, Pima County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.465699 -110.485519; 855 m (2,806 ft) elevation. Located northeast of Tucson in the corner of Pima County, a large tree now marks the former site of severely damaged Bingham Cienaga. Bingham Cienaga is managed by The Nature Conservancy who attempted 23 acres of wetland restoration of this ciénaga in the 1990s. The ciénaga has been mostly dry since 2003 because of drought and groundwater depletion (Davis 2012). Restoration of this ciénaga may ultimately need recovery of groundwater levels in the central San Pedro River valley. **R**
16. Bitter Lake Farm Ciénega. Sivinski and Tonne (2011). United States, New Mexico, Chaves County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 33.3837 -104.4214; 1,059 m (3,474 ft) elevation. The upper portion of this spring ciénaga habitat is small, and though the up-slope portion is intact, the lower portion is severely impacted by dikes, impoundments, and salt cedar (*Tamarix* sp.). **S**
17. Bitter Lake National Wildlife Refuge. Sivinski and Tonne (2011). United States, New Mexico, Chaves County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 33.4619 -104.4014; 1,068 m (3,504 ft) elevation. Containing 227 ha (560 ac) of remnant natural ciénaga habitat, this complex cluster of former sinkholes, lakes, resurgent creeks, spring runs, and seeps used to be one of the largest areas of aridland spring ciénagas in the Southwest, and although damaged, according to Sivinski and Tonne (2011, 42) it continues to support the greatest biological diversity of any ciénaga in New Mexico. **R**
18. Blue Spring Ciénaga. Sivinski, Robert, pers. comm. (2014). United States, New Mexico, Eddy County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 32.1803 -104.273; 1,000 m (3,282 ft) elevation. East of New Mexico's Carlsbad Caverns, this ciénaga appears to have been excavated into a large stock tank. **D**
19. Bog Hole Ciénega. Minckley et al. (2012). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.47 -110.62; 1,526 m (5,008 ft) elevation. Located southeast of Patagonia and northeast of Nogales, AZ at the headwaters of the Santa Cruz River, this ciénaga has been excavated into a large stock tank. **D**
20. Burro Ciénaga (also known as: Hawk Spring, Ojo de Inez, Cienaga Spring). USGS Topo Quad—Lordsburg, NM (2010). United States, New Mexico, Grant County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.4343 -108.3652; 1,631 m (5,351 ft) elevation. South of Silver City, NM, this is the severely incised 3.2 km-long portion of a live ciénaga on the Pitchfork Ranch currently undergoing restoration. Found along this incised waterway is Cienaga Spring, earlier named Ojo de Inez by John Russell Bartlett in 1851 (Bartlett, 1965) when it was "discovered" (by an Anglo). Describing a portion of what is now the Pitchfork Ranch: "The valley of the cañon leading to the Ojo de Inez ran up northwest, and was about 230 m wide near the spring or water-pool" (Report of Explorations and Surveys 1857). The federal- and state-listed Gila topminnow (*Poeciliopsis occidentails*), Chiricahua leopard frog (*Rana chiricahuensis*), and Wright's marsh thistle (*Cirsium wrightii*) have been reintroduced in this ciénaga. The obligate wetland species cardinal flower (*Lobelia cardinalis*) was discovered in the ciénaga in 2013. **R**
21. Bylas Spring (also known as: Geronimo-Bylas and Bylas Salt Spring). Minckley et al. (2012). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.16468 -110.114103; 806 m (2,643 ft) elevation. Formerly located southeast of Globe, AZ, east of Bylas, there is no longer any indication of a ciénaga at this location, which is now a floodplain. **D**
22. Canelo Hills Ciénega. Sartor, Karla, pers. comm. (2013). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.560000 -110.526696; 1,508 m (4,946 ft) elevation. Located

just short of 11 km directly south of Elgin, AZ, this is a broad marshy area with a clear stream bubbling up in the middle and running through it. This ciénaga is referred to as O'Donnell Creek basin by Hendrickson and Minckley (1985). There is a little more of the same ciénaga at 31.55 -110.52, elev. 1,521 m. **F**

23. Cascabel San Pedro Ciénega. Hendrickson and Minckley (1985). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.29 -110.37; 963 m (3,161 ft) elevation. Located east of Tucson and east of Cascabel, Cochise County, AZ, there is no longer a ciénaga at this location. **D**
24. Centerfire Bog. Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Catron County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.9118 -108.8347; 2,179 m (7,150 ft) elevation. Located about 5 mi northeast of Hulsey Cienaga, several waters occur along this channel. **F**
25. Ciénega Bercelo (also known as: Ciénaga los Nietos). Minckley et al. (2012). Mexico, Sonora, Cananea municipio. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.0226 -110.1355; 1,462 m (4,795 ft) elevation. Located southwest of Douglas, AZ, and northeast of Cananea, Sonora, a creek remains at this location, but the ciénaga has been converted to cropland and a dam impoundment. **D**
26. Ciénega Bonita (also known as: Witlocks Cienaga). (Eidenbach 2012). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.56 - 09.3; 1,085 m (3,559 ft) elevation. This point southwest of Duncan, AZ currently consists of a dry playa at which there is no longer any evidence of a spring or ciénaga. **D**
27. Ciénaga Creek. Hare, Trevor, pers. comm. (2014). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.0203 -110.4032; 977 m (3,206 ft) elevation. Located near Vail, AZ, Ciénaga Creek flows more than 48 km from near Sonoita to near Vail. Perhaps 16–24 km of the creek supports vast ciénagas along with cottonwood/willow gallery forests and mesquite bosques. Currently there are extensive ciénegas at the confluence of two main tributaries and a few smaller areas at the confluence of some of the drier tributaries. **F**
28. Ciénaga del Cuervo. Sivinski, Robert, pers. comm. (2013 United States, New Mexico, Catron County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.23 -109.02; 1,485 m (4,871 ft) elevation. Located northeast of Morenci, just inside the NM border, there is no longer a ciénaga anywhere near this point, only a narrow canyon with a creek. Ciénega del Guiso appears on the Military Map of New Mexico 1864 at 33.22 -108.98 and these two were likely one and the same. **D**
29. Ciénaga de Heradia. Sivinski, Robert, pers. comm. (2013). Mexico, Sonora, Cananea municipio. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.13 -110.21; 1,422 m (4,666 ft) elevation. This ciénaga occurs south of Sierra Vista, AZ, 10.5 km south of the border. There is currently a dry swale at this location, but with small ciénaga remnants up-drainage, mostly behind dams. **S**
30. Ciénaga de los Pinos. United States, Arizona, Pima County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.998207 -110.5930081; 1,065 m (3,495 ft) elevation. This ciénaga occurs 27.4 km (17 mi) west of Benson, near I-10. There appears to be a short spring run in an otherwise dry creek bed at this location. The adjacent valley floodplain is broad and may have once been a large ciénaga, but is now dry and covered in woody vegetation. **D**
31. Ciénaga del Macho (also known as: Ciénaga del Macho River). Pearce. (1965). United States, New Mexico, County. The location and condition of this ciénaga remain unknown to the authors. **D**
32. Ciénega La Palmita. Minckley et al. (2012). Mexico, Sonora, Cananea municipio. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.2393 -110.2884; 1,442 m (4,730 ft) elevation. This location is south of Sierra Vista, 10.5 km below the border. It appears that there is no longer a ciénaga here. **D**
33. Ciénega Mi Ranchito. Minckley et al. (2012). Mexico, Sonora, Cananea municipio. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.065000 -110.31; 1,573 m (5,162 ft) elevation. Located north of Cananea, Sonora, there is no longer a ciénaga here. **D**
34. Ciénega Molina (also known as: Rio San Rafael Ciénaga). Minckley et al. (2012). Mexico, Sonora, Cananea municipio. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.161 -110.331; 1,422 m (4,666 ft) elevation. Southeast of Santa Cruz, AZ, and 19.3 km (11.4 mi) south of the border, this ciénaga currently has a dam built across it. **S**
35. Ciénega Rio Magdalena. Sivinski, Robert, pers. comm. (2014). Mexico, Sonora, Nogales municipio. Aquatic ecoregion (river basin)—Sonora. Coordinates: 31.095 -110.91; 1,101 m (3,613 ft) elevation. Located between Agua Zarca and Cibuta, below Nogales, Sonora, there is no longer water here, but instead a dry drainage and agricultural fields. **D**
36. Ciénaga Springs. Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Socorro County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.8731 -107.0894; 1,878 m (6,163 ft) elevation. Located 27.4 km (17 mi) southwest of Socorro. **R**
37. Ciénaga-Town. Sivinski, Robert, pers. comm. (2014). United States, New Mexico, Hidalgo County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.695091 - 109.045125; 1,157 m (3,795 ft) elevation. This point in the Gila Valley between Virden and Duncan, AZ has long been converted to cropland. **D**
38. Ciénega del Burro Creek (also known as: Cienequilla Creek). Pearce (1965); Julyan (1996). United States, New Mexico, Union County. Aquatic ecoregion (river

basin)—US Southern Plains. Coordinates: 36.59 -103.00; 1,449 m (4,753 ft) elevation. Julyan (1996, 330–331) mentions both Seneca and Seneca Creek, 22.5 km northeast of Clayton, where the creek runs into Oklahoma. He notes that when freighters came through in the 1850s, they called it Jackass Swamp. This area is heavily farmed, with no suggestion of a live ciénaga. **D**

39. Ciénega El Tule. Minckley et al. (2012). Mexico, Sonora, Naco municipio. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.294 -110.28; 1,495 m (4,905 ft) elevation. Located south of Sierra Vista, AZ and 4 km across the border in Sonora, this ciénaga appears dead. Several large trees can be seen in Google Earth, but this site is otherwise covered with woody shrubs. **D**
40. Ciénaga Fresnal. Jones, Dave, pers. comm. (2013). Mexico, Chihuahua.,. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 31.04594 -107.530421; 1,181 m (3,875 ft) elevation. We learned of this ciénaga from our neighbor, Dave Jones, who lives in Casas Grandes, Chihuahua, but owns the Thorn Ranch south of our Pitchfork Ranch. He travels past this ciénaga regularly and informed us of its existence. We have not personally visited the property, but Google Earth imagery (viewed June 3, 2015) illustrates an approximately 7.4 km^2 (5 mi^2) triangular-shaped area that appears to have springs and ciénaga-like and riparian vegetation. This is on the south edge of El Fresnal playa, just NW of the small community or rancho of El Fresnal. The area looks quite dry in the 2013 imagery in Google Earth, but images from 8/26/2007 and some earlier coverages indicate much greener vegetation. **F**
41. Ciénega Springs. Hendrickson and Minckley (1985). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.7204 -109.7046; 979 m (3,213 ft) elevation. Located south of Safford, AZ, the main spring for this ciénaga is now captured in an impoundment called Dankworth Pond. **S**
42. Ciénega—Unnamed. Mexico, Sonora, Cananea municipio. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.174 -110.33014; 1,402 m (4,600 ft) elevation. Located in Mexico between Sierra Vista, AZ and Cananea, Sonora, the area appears dry, with the adjacent dam full of sediment. **D**
43. Ciénega Villa Verde. Minckley et al. (2013). Mexico, Sonora, Cananea municipio. Aquatic ecoregion (river basin)—Sonora. Coordinates: 31.140000 -110.007000; 1,492 m (4,896 ft) elevation. Located northeast of Cananea and south of Naco, Sonora, this ciénaga occurs near a large dam impoundment and cropland. Further upstream is the town of El Suez, which appears to be built at a spring [31.17 -109.98] that no longer functions as a ciénaga. S
44. Cieneguilla. Bandelier et al. (1966). United States, New Mexico, Unknown County. Aquatic ecoregion (river basin)—unknown. "Little Marsh" or "Little Marshy Meadow." This ciénaga has not been located by the authors and is likely dead. **D**
45. Cienequita Las Cienagas. Sartor, Karla, pers. comm. (2012). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.4745 -110.3546; 1,678 m (5,504 ft) elevation. Located approximately 72.4 km (45 mi) south of Tucson, this small ciénaga is fully functioning. **F**
46. Cloverdale Ciénaga. Sivinski and Tonne (2011). United States, New Mexico, Hidalgo County. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 31.4367 -108.9764; 1,643 m (5,390 ft) elevation. Cloverdale Ciénaga is located west of Antelope Wells, in the Bootheel, NM, in the southwest corner of Hidalgo County. This large, discontinuous area of wet valley bottom contains a 20.2 ha remnant of a formerly large ciénaga with extensive plant diversity. This ciénaga, now damaged by excavation, down-cutting, and pasturing, is currently undergoing comprehensive restoration. **R**
47. Cocospera Ciénega (Rorabaugh and others(2013). Mexico, Sonora, Imuris municipio. Aquatic ecoregion (river basin)—Sonora. Coordinates: 30.853826 -110.66469; 1,073 m (3,519 ft) elevation. Located west of Cananea, Sonora, there may remain a spring here, but this area is completely disturbed by agricultural fields, pastures, and farm ponds. Rorabaugh and others (2013) mention ciénegas on this ranch and state "federal reserve status for Rancho El Aribabi through México's federal La Comisión Nacional de Áreas Naturales Protegidas (CONANP) . . . was assigned to the ranch in May of 2011." See also http://elaribabi.com/. **R**
48. Cold Spring Ciénaga. Sivinski and Tonne (2011). United States, New Mexico, Grant County. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 32.5636 -108.0094; 1,538 m (5,047 ft) elevation. Located southeast of Silver City, this ciénaga is completely dead, having been dewatered by Hurley copper mill. (Sivinski, Robert, pers. comm., 2014). **D**
49. Comanche Springs Ciénaga. Hendrickson, Dean A., pers. comm. (2014). United States, Texas, Pecos County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 30.8815 -102.8787; 897 m (2,944 ft) elevation. Per Hendrickson, this ciénaga is in the middle of the city of Fort Stockton, long dry and functionally dead, although the city has a plan to restore it similar to what was done at Balmorhea. **S**
50. Cook's Lake. Minckley et al. (2013). United States, Arizona, Pinal County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.862 -110.72; 648 m (2,127 ft) elevation. South of Dudleyville, near agriculture fields, this ciénaga appears dead. **D**
51. Cook Spring. Sivinski and Tonne (2011). United States, New Mexico, Socorro County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 34.0476 -106.9375; 1,493 m (4,899 ft) elevation. Located only 4 km west of Socorro, the status of this ciénaga is unclear, but a small amount of ciénaga habitat is apparent on aerial imagery and it is presumably restorable. **R**

52. Croton Springs. The source of this information is misplaced. United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.161 -109.93; 1,262 m (4,141 ft) elevation. Located at the edge of the Wilcox Playa, 13.7 southwest of Wilcox, this ciénaga is dead. **D**
53. Cow Springs. Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Luna County. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 32.4121 -108.1793; 1,537 m (5,042 ft) elevation. Located approximately 42 km south of Silver City, this ciénaga is on private property, captured and capped to prevent undermining the nearby ranch headquarters. "Early on, the spring or 'Ojo' was a deep well in the center of a plain, depressed somewhat below ground level. Several holes have been dug about 1.5 m (5 ft) around the natural spring to increase access to the water supply. The edge of the ojo is boggy and full of rushes. The water is good and slightly sulfurous, but full of vegetable matter and microscopic life. The evaporation of the surface water appears to keep pace with the bubbling up from the spring, since there is no stream emitted from it, a slightly marshy condition of the ground being the only effect" (Report for Explorations and Surveys [1857, 21]). The report notes Ojo de la Vaca's importance in the district where the supply of water is limited as but only one of three [water] sources immediately on the present wagon road. In the 1800s, this ciénaga was central to travelers to and from any of the four directions. **R**
54. Croton Springs. Hendrickson and Minckley (1985). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.17 -109.93; 1,264 m (4,147 ft) elevation. Located between Benson and Wilcox, 1.6 km south of I-10, there is no longer a spring or ciénaga at this location. **D**
55. Cuatro Ciénegas. Meyer (1973). Mexico, Coahuila de Zaragoza, Cuatro Ciénegas municipio. Aquatic ecoregion (river basin)—Rio Salado. Coordinates: 26.909135 -102.063279; 714 m (2,344 ft) elevation. This large ciénaga complex is located south of Big Bend, TX, and consists of thousands of acres of wetlands in a basin at the eastern edge of the Chihuahuan desert in the Mexican state of Coahuila. These are fed by abundant subterranean water that emerges at the surface in numerous small and large spring runs, seeps, and sink-hole ponds. No attempt is made here to catalog the spring, lake, and wetland names in this large artesian basin. The valley of Cuatro Ciénegas has the greatest number of endemic species of any place in North America and with its diverse complex of thousands of geothermal springs, marshes, lakes, and streams, it ranks near the Galápagos Islands in terms of the world's unique ecosystems (Meyer 1973). **F**
56. Dead Oryx Mound Spring. Sivinski and Tonne (2011). United States, New Mexico, Lincoln County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.417 -106.2864; 1,317 m (4,320 ft) elevation. This is a very small pool with little vegetation and barely alive. **S**
57. Diamond-Y Ciénaga. Hendrickson, Dean A., pers. comm. (2014). United States, Texas, Pecos County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 31.02149 -102.90533; 838 m (2,748 ft) elevation. Located in Pecos County, the 1,603 ha Diamond Y Spring Preserve is now owned by The Nature Conservancy and provides the only remaining natural habitat for the federally listed Leon Springs pupfish (*Cyprinodon bovinus*) and the Pecos Gambusia (*Gambusia nobilis*). **F**
58. Douglas Valley Ciénaga. Hendrickson and Minckley (1985). Mexico, Sonora, Agua Prieta municipio. Aquatic ecoregion (river basin)—Sonora. Coordinates: 31.2243 -109.6; 1,261 m (4,137 ft) elevation. Occurring 6.4 km (4 mi) northwest of Douglas, AZ, this drainage is now dry. **D**
59. El Jarral Ciénega. Meyer (1973). Mexico, Sonora, Cananea municipio. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.22 -110.34; 1,424 m (4,671 ft) elevation. Known to have existed in the late 1970s and located 37 km (23 mi) south of Sierra Vista, AZ, in Sonora, this location is a dry, broad drainage that no longer supports a ciénaga. **D** (Meyer 1973).
60. Empire Ranch (also known as: Ciénega Creek, Empire Ranch, and Ciénega Ranch (Minckley et al. 2013). USGS Topo Quad-Empire Mtn. 15-min series (1958). United States, Arizona, Pima County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.7879 -110.6400; 1,416 m (4,646 ft) elevation. The Empire Ranch is located approximately 35.4 km (22 mi) from Green Valley. Near the Empire Ranch Airport, on the west side of Ciénega Creek in Las Ciénegas National Conservation Area. There is extensive ciénaga habitat on this property (now BLM reserve). **F**
61. Fairbank Ciénaga. Hendrickson and Minckley (1985). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.717647 -110.196925; 1,178 m (3,850 ft) elevation. Located on the Babocomari River at its confluence with the San Pedro River, this site is now a mere valley bottom, and no longer supports a ciénaga. **D**
62. Faywood Ciénaga. Sivinski and Tonne (2011). United States, New Mexico, Grant County. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 32.5613 -107.9875; 1,537 m (5,042 ft) elevation. Located some 37 km (23 mi) southeast of Silver City, this ciénaga is no longer functional. Although still wet, water is piped down from its original source up-canyon. **D**
63. Feldman-San Pedro Ciénaga. Hendrickson and Minckley (1985). United States, Arizona, Pinal County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.84 -110.71; 661 m (2,168 ft) elevation. Located between Dudleyville and Mammoth, 78.9 km (49 mi) northeast of Tucson, this is now only a valley bottom, and is no longer a ciénaga. **D**
64. Fort Grant Ciénaga. Hendrickson and Minckley (1985).

United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.58 -109.97; 1,380 m (4,526 ft) elevation. Located just 2.4 km (1.5 mi) from the Graham County seat, this site is no longer a ciénaga. **D**

65. Garden Canyon Ciénega. Minckley et al. (2012). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.454 -110.376; 1,896 m (6,222 ft) elevation. An on-site inspection is necessary to confirm the past occurrence of a ciénaga here, but this location, 13.57 km (8 mi) southwest of Sierra Vista, appears to no longer support a ciénaga. **D**
66. Greenwell Slough Ciénaga. Minckley et al. (2012). United States, Arizona, Yavapai County. Aquatic ecoregion (river basin)—Gila. Coordinates: 34.716 -111.919; 604 m (1,983 ft) elevation. Located a mere 11.3 km (7 mi) north of the Scottsdale airport and just north of four large subdivisions, this site appears dry. **D**
67. Guilez Spring (also known as: Tula Pond). Sivinski and Tonne (2011). United States, New Mexico, Otero County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.0599 -106.1537; 1,263 m (4,143 ft) elevation. This site is an aridland spring with a 15.24 m (50 ft)-diameter pond that has been damaged by recreational use, exotic fish introduction, and road construction. Recent policy changes by the Department of Defense may well prohibit further damage. **R**
68. Harden Ciénaga Creek. Minckley et al. (2013). United States, Arizona, Greenlee County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.197000 -109.125; 1,257 m (4,123 ft) elevation. Located 24.1 km (15 mi) northeast of Clifton in Greenlee County, the coordinates appear wrong, being too far to the east and up-slope of an extremely lush canyon. Although there is no evidence of a nearby ciénaga, because of the vegetation, location of multiple canyons, distance from development, nearness to another lush riparian canyon up-channel, and a well-established farming operation 3.2 km (2 mi) to the northwest, an on-site inspection of this isolated area may well identify wetlands. Although speculative, a tentative classification of restorable seems warranted. **R**
69. Hare Mound Spring. Sivinski and Tonne (2011). United States, New Mexico, Lincoln County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.409 -106.2932; 1,312 m (4,305 ft) elevation. This spring, a mere 25 cm in diameter (10 in), is the smallest of five in a cluster and is going naturally extinct (Sivinski, pers. comm, 2013). **D**
70. Heron Spring Ciénega. Minckley et al. (2013). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.352556 -110.576237; 1,430 m (4,693 ft) elevation. A small pond remains at this site, which no longer supports a ciénaga or riparian vegetation. This site is damaged by livestock. **S**
71. Hooker Ciénega. Hendrickson and Minckley (1985). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.51 -110.04; 1,338 m (4,389 ft) elevation. Located some 48.3 km (30 mi) southwest of Safford, this ciénaga is dead. **D**
72. Horseshoe Canyon Ciénaga. Sivinski, Robert, pers. comm. (2013). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.76 -109.06; 1,298 m (4,258 ft) elevation. Located near the AZ/NM border, 69.2 km (43 mi) northeast of Douglas, this ciénaga is completely dry. **D**
73. Howard Ciénaga. Google Maps Satellite View (2013). United States, New Mexico, Grant County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.9801 -108.6564; 1,432 m (4,699 ft) elevation. Surrounded by buildings on a farm, this ciénaga appears dead on Google Earth, likely from pumping (Sivinski, pers. comm., 2014). **D**
74. Hulsey Ciénaga. Google Maps Satellite View (2013). United States, New Mexico, Catron County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.863700 -108.9019; 2,121 m (6,959 ft) elevation. This location is under 8 km northeast of Luna, in an unincorporated village in northwest Catron County, NM, 11.3 km (7 mi) from the NM/AZ border, 33.8 km (21 mi) from Reserve on the San Francisco River, and east of the road to Bastion Ranch. On Google Earth, there appears to be a string of 18 wet spots, a good deal of water, agriculture and impoundments; although unclear, this is likely a functional ciénaga. **F**
75. Indian Hot Spring (also known as: Eden Hot Springs). Minckley et al. (2013). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.9988 -109.9025; 849 m (2,785 ft) elevation. Located near Fort Thomas, 25.8 km (16 mi) northwest of Safford, this spring is highly disturbed and overrun by salt cedar, but may be salvageable. **S**
76. Jaques Marsh. Sivinski, Robert, pers. comm. (2013). United States, Arizona, Navajo County. Aquatic ecoregion (river basin)—Colorado. Coordinates: 34.1889 -109.9826; 2,067 m (6,782 ft) elevation. Just under 8 km (5 mi) north of Pinetop-Lakeside, this location appears to be obliterated by an agricultural field (Sivinski, pers. comm., 2013). **D**
77. Kennecott Cold Spring. Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Grant County. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 32.5647 -108.0078; 1,539 m (5,050 ft) elevation. As with the other three desert springs and ciénagas clustered at the dry mouth of the Rio Mimbres, this one also has been dried up by wells dug to supply water to the copper mill at Hurley (Sivinski, pers. comm., 2013). **D**
78. Kennecott Warm Spring. Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Grant County. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 32.5633 -108.0078; 1,536 m (5,040 ft) elevation. This ciénaga is completely dead, drained in

service of the Hurley copper mill (Sivinski, pers. comm, 2014). **D**

79. Kewa Marsh. Sivinski and Tonne (2011). United States, New Mexico, Sandoval County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 35.5459 -106.3516; 1,691 m (5,548 ft) elevation. Located 40.2 km (25 mi) west of Santa Fe and 8 km north of Santo Domingo Pueblo, this is a significant, extensive 2.6 km (1.6 mi)-long, 202 ha (500 ac), functional ciénaga. **F**
80. La Cebadilla Springs. Source unknown. United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.144 -110.4118; 1,453 m (4,766 ft) elevation. Located 22.5 km (14 mi) north and slightly west of Benson, AZ, this little-known ciénaga has live water and is functioning as well as most of the few ciénagas that remain. It would benefit from restoration. This coordinate indicates a spot on dry hills that has neither a spring nor a ciénaga, although there is an area about a mile to the northeast (32.1571 - 110.4054) with a grassy bottom and a few trees. The location and identical name to ciénaga #81, require further inquiry. **F**
81. La Cebadilla Spring. Minckley et al. (2013). United States, Arizona, Pima County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.2448 -110.6881; 830 m (2,724 ft) elevation. Located 24.1 km (15 mi) east of downtown Tucson, 4.8 km (3mi) east of the census-designated place of Tanque Verde and among well-spaced, large homes on multiple-acre lots, many with swimming pools, this area has two spring-fed ponds where ciénaga habitat has been excavated (destroyed) to make the ponds. Restoration is clearly called for. **R**
82. La Cienaga de San Vicente. Martinez, D. H. (1785), *cited in* Alford (1982). United States, New Mexico, Grant County. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 32.77 -108.28; 1,808 m (5,932 ft) elevation. Formerly occupying the site that is now Silver City, there were dozens of springs that fed the periphery of the extensive meadowlands of the Silver City floodplain at the confluence of the Silva and Piños Altos Creeks, a location frequented by the Apache. Floods in 1895 and 1902 transformed the street into the 54 ft-deep "Big Ditch" that now cuts through the town in lieu of Main Street (Alford, 1982). **D**
83. La Fresna Ciénega (also known as: Los Fresnos, Rancho Los Fresnos). Esquer, Antonio and T. Hare, pers. comm. (2013); Rorabaugh et al. (2013). Mexico, Sonora, Santa Cruz municipio. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.28276736 -110.390000; 1,501 m (4,925 ft) elevation. The coordinates are of the El Fresno ranch headquarters. There is a small spring seep visible in Google Earth imagery dated 4/2013 updrainage 4–5 km (3 mi) to the northwest (at 31.314118 -110.426764) in the area apparently referred to by Rorabaugh et al. (2013) as having "well-developed ciénegas and riparian corridors along Portrero del Alamos, Arroyo Los Fresnos, Arroyo Los Alisos, Agua Dulce, and other drainages (Varela-Romero et al. 1992)." See also http://www.naturalia.org.mx **R**
84. Lake Valley Ciénaga. Sivinski and Tonne (2011). United States, New Mexico, Sierra County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 32.7581 -107.5353; 1,551 m (5,090 ft) elevation. This site at one time consisted of intermittent runoff from Berrenda Creek which was captured in Lake Valley sediments and slowly discharged into a perennial spring run at the base of Lake Valley to create ciénaga wetlands. Lake Valley Cienaga is now deeply incised; the ciénaga is gone and riparian woodlands remain. **D**
85. Lang Ciénega (also known as: Ciénega Spring). Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Hidalgo County. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 31.335098 -108.816266; 1,572 m (5,158 ft) elevation. Located 25.8 km (16 mi) west of Antelope Wells, NM, approximately 90% of the ciénega lies in US and 10% in Mexico, covering 24.3 ha (60 ac) and 4 km (2.5 mi) long, this important ciénaga has high plant diversity and no problem with invasive plants. **F**
86. Las Ciénagas. Hare, Trevor, pers. comm. (2014). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.0203 -110.4032; 977 m (3,206 ft) elevation. Located near Vail, AZ, the condition of this ciénaga is similar to Ciénega Creek, number 27 above. **R**
87. Leslie Creek Ciénaga. Hendrickson and Minckley (1985). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Yaqui. Coordinates: 31.591755 -109.488391; 1,433 m (4,701 ft) elevation. Located 30.6 km (19 mi) north of Douglas, this location is on the 1,119 ha (2,765 ac) Leslie Canyon National Wildlife Refuge established in 1988 to protect two of the eight native fish species of the Rio Yaqui watershed, the Yaqui chub (*Gila purpurea*) and the Yaqui topminnow (*Poeciliopsis occidentalis sonoriensis*). Wildlife Refuge Specialist Chris Lohrengrel (pers. comm., May 20, 2015) considers the location for which we provide coordinates to be most likely, based on current vegetation and soils, to have had a ciénaga. **R**
88. Lewis Springs-San Pedro (also known as: Lewis Springs Ciénega and Bull Run). Hendrickson and Minckley (1985). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.578500 -110.1398; 1,234 m (4,050 ft) elevation. Located 27.4 km northeast of Sierra Vista, AZ, and some 400 m (1,312 ft) east of the San Pedro River near Saint David Cienaga, this ciénaga is slightly less than 0.8 ha (1 ac) in area and is one of the few known locations of the obligate wetland species cardinal flower (*Lobelia cardinalis*). It is also the location for the critically imperiled [in Arizona] Arizona eryngo (*Eryngium sparganophyllum*). **F**
89. Los Ojos (also known as: Ojos de Agua Caliente). Minckley et al. (2013). Mexico, Sonora, Agua Prieta municipio. Aquatic ecoregion (river basin)—Guzman—

Samalayuca. Coordinates: 31.2827 -108.9915; 1,753 m (5,750 ft) elevation. Located less than 4.8 km (3 mi) below the international border and 53 km (33 mi) east of Douglas, AZ, this appears to be a living ciénaga. **F**

90. Main Mound Spring. Sivinski and Tonne (2011). United States, New Mexico, Lincoln County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.4257 -106.2848; 1,325 m (4,347 ft) elevation. The largest of five clustered springs 186.7 km (116 mi) south of Albuquerque, in the northern part of the White Sands Desert, this ciénaga provides habitat for the White Sands pupfish (*Cyprinodon tularosa*) and healthy ciénaga vegetation. **F**
91. Malpais Spring Ciénega. U.S. Dept. of Defense. Sivinski and Tonne (2011). United States, New Mexico, Otero County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.2786 -106.3101; 1,262 m (4,140 ft) elevation. Located in the north portion of the White Sands Desert and 53.1 km (33 mi) northwest of Alamogordo, both the size and healthy condition of this reclaimed ciénaga are rare. This ciénaga provides habitat for the White Sands pupfish (*Cyprinodon tularosa*). **F**
92. Martin Ciénaga. Hough, W. (1907). United States, New Mexico, Catron County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.8189 -108.9545; 2,150 m (7,055 ft) elevation. This location is in Luna, covered by a road and next to the asphalt parking lot for the USDA Forest Service Apache National Forest. **D**
93. Mescal Warm Spring. Hare, Trevor, pers. comm. (2014). United States, Arizona, Pinal County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.148458 -110.635187; 760 m (2,494 ft) elevation. Located in the Needles Eyes Wilderness area in the Mescal Mountains, this ciénaga is spring-fed on a mesa above Mescal Creek with a hanging garden below along the creek. **F**
94. Monkey Spring. Minckley et al. (2013). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.639 -110.711; 1,387 m (4,550 ft) elevation. Located less than 9 km (5.6 mi) southwest of Sonoita, there is no ciénaga at this point, but there does appear to be a small spring pool and acequia to the southeast at 31.63 -110.70 elev. 1,415 m. **R**
95. Mule Spring. Hayes, Frank pers. comm. (2014). United States, New Mexico, Grant County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.09859 -108.981535; 1,635 m (5,365 ft) elevation. Located near a long-occupied pre- and post-Classic Mimbres cultural site with a long history of occupancy, many ciénaga plants represented. **S**
96. Munson's Ciénaga (also known as: San Simon-Gila). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.826 -109.627; 904 m (2,965 ft) elevation. Located 8 km east of Safford, and 1.6 km (1 mi) north of Solomon, AZ, this site is now merely a floodplain that has been completely converted to cropland.(Sivinski, pers. comm., 2014). **D**
97. North Mound Spring. Sivinski and Tonne (2011). United States, New Mexico, Lincoln County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.4353 -106.2896; 1,330 m (4,365 ft) elevation. Part of a cluster of springs, North Mound Spring is only 76 cm (30 in) across, consisting of a gypsum mound spring with little vegetation. **S**
98. Oak Tree Ciénaga. Hare, Trevor, pers. comm. (2014). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.0203 -110.4000; 977 m (3,206 ft) elevation. This ciénaga exists along Ciénega Creek at its confluence with Oak Tree Canyon. **F**
99. Obed Meadow Ciénaga. Google Maps Satellite View (2013). United States, Arizona, Navajo County. Aquatic ecoregion (river basin)—Colorado. Coordinates: 34.917 -110.390; 1,527 m (5,009 ft) elevation. Located 128.7 km (80 mi) east of Flagstaff and just over 3.2 km (2 mi) south of Joseph City, on Google Earth Obed Meadow appears undisturbed, but with no cienaga. **D**
100. Ojo de Agua. Minckley et al. (2013). Mexico, Sonora, Cananea municipio. Aquatic ecoregion (river basin)—Sonora. Coordinates: 30.96 -110.232; 1,486 m (4,874 ft) elevation. Located east of Cananea and 40.2 km (25 mi) south of the border, this former ciénaga has been replaced by a salt flat reservoir. **D**
101. Ojos de Arrey (also known as: Ojo del Rey). Sivinski, Robert, pers. comm. (2013). Mexico, Chihuahua, Galeana municipio. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 30.05948 -107.590129; 1,498 m (4,915 ft) elevation. Located 5.8 km (3.6 mi) southeast of Galeana, this appears to be a large spring ciénaga on aerial imagery. **F**
102. Ojo de Huelos (also known as: Ojo Alamo). Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Valencia County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 34.7317 -106.5461; 1,650 m (5,414 ft) elevation. Valencia Co. Located 19.3 km (12 mi) southeast of Los Lunas, this ciénaga is currently almost completely dry and probably not restorable. **D**
103. Ojito de San Juan. Torres, Frank, pers. comm. (2014). United States, New Mexico, Grant County. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 32.89 -107.84; 2,152 m (7,060 ft) elevation. Coordinates estimated (believed within several km). Previously unknown to anyone, this small ciénaga is located 8 km (5 mi) north of San Juan Church near the Mimbres River. Ojito de San Juan is currently unfenced and services a 1.9 m^3 (67 ft^3) drinker for cattle. It is referred to locally as an *ojito* or "little spring." Torres states that this site is used to water cattle and is surrounded by black soil and what he describes as ciénaga-like vegetation. A site visit is planned, and it seems probable this small ciénaga would benefit from fencing, a drinker, and restoration at little cost; this would also be of benefit for watering cattle. **R**

104. Ojo Vareleno. Sivinski, Robert, pers. comm. (2013). Mexico, Chihuahua, Casas Grandes municipio. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 30.4006 -107.9847; 1,529 m (5,018 ft) elevation. Located 104.6 km (65 mi) south of the international border and 4 km (2.5 mi) northwest of Casas Grandes, Ojo Vareleno is partially developed but currently represents a good living ciénaga. **R**
105. Palomas Canyon Ciénega. Sivinski and Tonne (2011). United States, New Mexico, Sierra County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.1713 -107.5601; 1,643 m (5,392 ft) elevation. Located 82 km (51 mi) northeast of Silver City, Palomas Canyon Cienaga is a little-known seep cienaga (300 m x 30 m, 984 ft x 98 ft) that is largely intact. **F**
106. Parker Canyon Ciénega. Minckley et al. (2013). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.421 -110.467; 1,603 m (5,259 ft) elevation. Located 22.5 km southwest of Sierra Vista and less than 1.6 km (1 mi) west of Parker Canyon Lake, this location is in a canyon with vegetation, but no ciénaga is apparent. Although inspection is needed to confirm, this ciénaga appears dead. **D**
107. Potrero Canyon Ciénaga. Minckley et al. (2013). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.39 -110.957; 1,113 m (3,653 ft) elevation. This location is 8 km (5 mi) south of Rio Rico, midway toward Nogales. From Google Earth, there no longer appears to be a ciénaga at this site, although inspection is needed to confirm. **D**
108. Pipe Springs Ciénega. Makings (2013). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Yaqui. Coordinates: 31.33528 -109.260516; 1,135 m (3,724 ft) elevation. This ciénaga is mentioned in Makings (2013) and is on a refuge managed by the staff of the San Bernardino National Wildlife Refuge in Cochise County, AZ. Bill Radke, manager of the Refuge (pers. comm., 2014) states that there are several capped steel pipes in this area that flowed freely in the past and may have supported ciénaga habitats. Dean Hendrickson collected fishes, Yaqui chub (*Gila purpurea*) and Yaqui topminow (*Poeciliopsis occidentalis sonoriensis*), at Pipe Springs Ciénega (he recalls an old well casing) around 1979–80 (pers. comm., 2015). Chris Lohrengel, Wildlife Refuge Specialist at San Bernardino/Leslie Canyon National Wildlife Refuge (pers. comm., 2015) reports that the area would lend itself to a ciénaga and that there is an impoundment downstream that is ciénaga habitat with ciénaga-obligate plants associated with it. Due to location and other considerations, restoration is likely. **R**
109. Quetes de la Ciénaga. Bandelier et al. (1966). United States, New Mexico, unknown County. Aquatic ecoregion (river basin)—unknown. Presumably NM. We misplaced the specific page, but initially found this ciénaga mentioned in Bandelier's 1892 reports (Bandelier et al. 1966). The location and condition of this ciénaga is unknown, but it is presumed dead. **D**
110. Redhead Marsh. Google Maps Satellite View (2013). United States, Arizona, Navajo County. Aquatic ecoregion (river basin)—Colorado. Coordinates: 34.29504 -110.07483; 1,914 m (6,280 ft) elevation. Redhead Marsh is located 6.4 km (4 mi) north of Show Low. There is nearby water and what appears to be a large built impoundment 2.6 km (1.6 mi) southeast of Redhead Marsh. It is possible, but doubtful that a ciénaga occurs here. **D**
111. Redington-San Pedro Ciénaga. Hendrickson and Minckley (1985). United States, Arizona, Pima County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.43 -110.50; 886 m (2,908 ft) elevation. Located 22.5 km southeast of San Manuel, this ciénaga no longer exists. **D**
112. Oasis Dairy Ciénaga. Sivinski and Tonne (2011). United States, New Mexico, Chaves County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 33.31449 -104.3712; 1,390 m (4,560 ft) elevation. This unnamed spring and associated large ciénaga is a part of the Roswell Artesian Basin Ciénegas, 11.3 km (7 mi) east of Roswell, Chaves County, NM, opposite Bottomless Lakes State Park. The ciénaga is rapidly declining due to agricultural pumping and appears to be dying (Sivinski, pers. comm., 2014). **S**
113. Phantom Lake Spring (also known as: Phantom Springs Cave and Ojo la Loma on an early map). Hendrickson, Dean A., pers. comm. (2014). United States, Texas, Jeff Davis County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 30.9348 -103.8486; 1,060 m (3,478 ft) elevation. This is actually a group of springs that pour from a 141 m (88 ft)-deep cave at the foot of the lower Cretaceous limestone bluff 6.4 km (4 mi) west of Toyahvale. It is the deepest underwater cave system known in the United States. The cave feeds the 6.4 km (4 mi)-long Phantom Lake Canal built in the 1940s that carries water for irrigation, although irrigation wells have caused the spring flow to decline from $450^{l/s}$ in 1932 to $140^{l/s}$ in 1976. The cave is the home of two federally and Texas-listed endangered fish: Comanche Springs pupfish (*Cyprinodon elegans*) and Pecos gambusia (*Gambusia nobilis*). https://tshaonline.org/handbook/online/articles/rpp06. **F**
114. Dexter Ciénega. Sivinski and Tonne (2011). United States, New Mexico, Chaves County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 33.2407 -104.37015; 1,052 m (3,452 ft) elevation. Located adjacent to the Dexter National Fish Hatchery, this ciénaga is severely impacted by roads, dikes, impoundments, and changed hydrology from hatchery operations. **S**
115. BLM Overflow Wetland. Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Chaves County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 33.3089 -104.3443; 1,050 m (3,444 ft) elevation. This wetland consists of a large salt marsh and ciénaga created in a valley bottom flooded by spring flow from

adjacent sinkhole lakes that overlap part of Bottomless Lakes State Park. **F**

116. BLM North Dexter Ciénaga. Sivinski and Tonne (2011). United States, New Mexico, Chaves County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 33.26915 -104.36353; 1,047 m (3,434 ft) elevation. Located 8 km north of Dexter, a spring at the head of a valley created a ciénaga over 1.6 km (1 mi) long. This was dried by a well, but after purchase by BLM, this ciénaga is slowly recovering. **R**
117. Rio Rico Ciénega. Minckley et al. (2012). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.478 -110.988; 1,038 m (3,405 ft) elevation. Located 2.4 km north of Rio Rico, this site appears to be on the edge of an abandoned agricultural field. This former ciénaga is dead. **D**
118. Saint David-San Pedro Ciénaga (also known as: Tenneco Marsh and Miller's Marsh). Hendrickson and Minckley (1985). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.8422 -110.2235; 1,260 m (4,134 ft) elevation. Located 6.4 km south of St. David, AZ, just west of the San Pedro River, this is a large ciénaga (approximately 141.6 ha) with a 4 km perimeter that contains approximately 30.4 ha of permanent water. This is a well-preserved, recovering ciénaga, managed by the BLM as part of the San Pedro Riparian National Conservation Area. **F**
119. Saracachi Ciénega. Hare, Trevor, pers. comm. (2014). Mexico, Sonora, Cucurpe municipio. Aquatic ecoregion (river basin)—Sonora. Coordinates: 30.3591 -110.5986; 941 m (3,087 ft) elevation. Located less than 3.2 km west of Agua Fria, and 103 km south of the AZ border, this is a large ciénaga, greater than 81 ha and in excellent condition. **F**
120. San Bernardino Ciénega (also known as: San Bernardino Ranch and Slaughter Ranch). Minckley and Brunelle (2007). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Yaqui. Coordinates: 31.337369 -109.261762; 1,136 m (3,727 ft) elevation. This former cienaga is 27.4 km east of Douglas on the U.S. side of the border. This ciénaga was dried by severe erosion and channel incision that lowered the water table and dried up the wetland. The only wet, living part of this ciénaga, artificially maintained by an artesian well, is on the Sonoran side of the border. **D**
121. San Pedro-Complex. Hendrickson and Minckley (1985). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.47 -110.11; 1,291 m (4,234 ft) elevation. Equidistant between Sierra Vista and Bisbee, and less than 4.8 km north of Herford, this is a very complicated riparian system, very little of which can currently be called a ciénaga, but it is likely restorable. **R**
122. San Simon Ciénaga (also known as: Cienaga de Sauz). Hendrickson and Minckley (1985). United States, New Mexico, Hidalgo County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.0746 -109.0481; 1,177 m (3,860 ft) elevation. Located on the NM/AZ border, 22 km (15.5 mi) north of Rodeo, NM. This was one of the most extensive ciénagas in the Southwest, being 8 km (5 mi) in length and up to 400 m (1312ft) wide. It has been completely dried by groundwater pumping in agricultural fields at the foot of the Chiricahua Mountains (Sivinski and Tonne 2011). The valley around this point is dry and there is no longer any chance of a ciénaga occurring here, despite expensive, now abandoned, government efforts. **D**
123. Santa Cruz River Ciénega. Minckley et al. (2013). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.36 -110.59; 1,446 m (4,743 ft) elevation. Located 33.8 km (21 mi) northeast of Nogales, Sonora and 4.8 km north of Santa Cruz, but in the US, a small ciénaga remains northeast of this point at 31.37 - 110.58. **R**
124. City of Santa Rosa Ciénagas. Sivinski and Tonne (2011). United States, New Mexico, Guadalupe County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 34.9426 -104.6762; 1,412 m (4,634 ft) elevation. There are 11 separate springs clustered in this basin. In order to maintain consistency with other ciénegas listed that also consist of multiple features, the many springs are treated as one. **F**
125. Seco Canyon Ciénega. Sivinski and Tonne (2011). United States, New Mexico, Sierra County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.0899 -107.5582; 1,682 m (5,518 ft) elevation. This ciénaga is located approximately 27.4 km (15 mi) west of Truth or Consequences, NM. This is an undisturbed, 80.5 m (264 ft)-long spring seep ciénaga. **F**
126. Sharp Spring. Minckley et al. (2013). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.358 -110.581; 1,426 m (4,679 ft) elevation. Located 25.7 km (16 mi) southeast of Patagonia and less than 3.2 km (2 mi) from the international border, this site is near what appear on Google Earth to be abandoned agricultural fields and no ciénaga. **D**
127. Sheehan property Ciénaga. Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Guadalupe County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 34.9197 -104.6723; 1,458 m (4,785 ft) elevation. This site contains a large spring and spring run within 2.4 ha (5.9 ac) of healthy cienaga. **F**
128. Sheehy Spring. Minckley et al. (2013). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.373 -110.569; 1,467 m (4,813 ft) elevation. Located 25.7 (16 mi) km southeast of Patagonia and almost 4.8 km (3 mi) from the international border, this wetland is similar to Sharp Spring; there is no longer a ciénaga at this location. **D**
129. Shorthorn Spring. Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Sierra County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 32.7578 -107.3968; 1,366 m (4,483 ft)

elevation. Located 25.7 km (16 mi) northeast of Hatch, this spring seep is captured for a cattle drinker, although overflow wets a 30 x 10 m (98 ft x 32 ft) grassy area. **R**

130. Sink Hole Ciénaga. Sivinski and Tonne (2011). United States, New Mexico, Chaves County. Aquatic ecoregion (river basin)—Pecos. Coordinates: 33.2789 -104.3502; 1,050 m (3,445 ft) elevation. This small habitat was created in the mid-1990s when the site was opened into a small ciénaga. **F**
131. Sonoita Ciénaga. Minckley and Brunelle (2007). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.53 -110.77; 1,222 m (4,010 ft) elevation. Located 1.6 km (1mi) southwest of Patagonia, AZ, it appears that the entire ciénaga has been converted to a hay meadow (Sivinski, pers. comm., 2013). **D**
132. Sonora Ciénaga. Sivinski, Robert, pers. comm. (2013). Mexico, Sonora, Fronteras municipio. Aquatic ecoregion (river basin)—Sonora. Coordinates: 30.758468 -109.602612; 1,190 m (3904 ft) elevation. Located less than 4.8 km (3 mi) northeast of Esqueda, Sonora, there is a remnant of a disturbed ciénaga upstream of an impoundment with associated hay fields and cropland. **R**
133. South Mound Spring. Sivinski and Tonne (2011). United States, New Mexico, Lincoln County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.406 -106.2946; 1,309 m (4,295 ft) elevation. The second largest of five springs, South Mound Spring is sparsely vegetated and fenced from feral horses. **S**
134. Stevens Ciénaga. Hough (1907). United States, Arizona, Navajo County. Aquatic ecoregion (river basin)—Colorado. Coordinates: 34.1296 -109.8962; 2,193 m (7,196 ft) elevation. This ciénaga is identified from a century-old archaeology paper. There no longer appears to be a ciénaga in this area 3.5 km (2.1 mi) east of Pinetop, AZ. While it is arguably too high in the mountains to be listed here, W. Hough's sketch indicates a large body of water in a valley-like setting that at one time supported a sizable number of people in a large open space. **D**
135. Sulphur Springs. Hendrickson and Minckley (1985). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.09 -109.80; 1,274 m (4,180 ft) elevation. Located 14.5 km (9 mi) south of Wilcox, on the edge of the large Faria Dairy and numerous large agricultural fields, there may still be a spring at this location, but no ciénaga currently exists here. This habitat is unlikely to be restored due to groundwater pumping. **D**
136. Sycamore Ciénaga. Minckley and Brunelle (2007). United States, Arizona, Maricopa County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.66 -111.66; 453 m (1,486 ft) elevation. Located northeast of Fountain Hills, this area is currently completely dry. **D**
137. Tavasci Marsh (also known as: Tavasel Marsh). Google Maps Satellite View (2013); Minckley et al. (2013). United States, Arizona, Yavapai County. Aquatic ecoregion (river basin)—Gila. Coordinates: 34.7781 -112.0221; 1,023 m (3,357 ft) elevation. Just over 3 km east of Clarkdale, there is a large marsh in what appears to be an old oxbow on the Verde River less than 100 m (328 ft) west at 34.77 - 112.02. **F**
138. The Ciénaga. Google Maps Satellite View (2013). United States, Arizona, Apache County. Aquatic ecoregion (river basin)—Colorado. Coordinates: 34.27851 -109.394614; 1,904 m (6,248 ft) elevation. This site is located approximately 2.4 km (1.5) west of Hwy 180 between St. Johns and Eager. **F**
139. The Narrows-San Pedro Ciénaga. Hendrickson and Minckley (1985). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.11 -110.30; 1,034 m (3,391 ft) elevation. Located 16 km (10 mi) north and less than 0.5 km (0.3 mi) east of the San Pedro River, this area is completely dry and no ciénaga remains here. **D**
140. Tres Alamos Wash Ciénegas. Minckley et al. (2013). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.037 -110.311; 1,050 m (3,446 ft) elevation. Located 8 km (5 mi) north of Benson, just east of the San Pedro River, this area is now completely dry. **D**
141. Turkey Creek Ciénaga. Hendrickson and Minckley (1985). United States, Arizona, Santa Cruz County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.5395 -110.5128; 1,526 m (5,006 ft) elevation. This site occurs very close to Canelo Hills, and is likely dead. **D**
142. Unnamed Ciénega #1. Hendrickson and Minckley (1985). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.68 -109.13; 1,336 m (4,382 ft) elevation. Located 54.7 km (34 mi) northeast of Douglas, there is currently no ciénaga at this location. **D**
143. Unnamed Ciénega #2. Mapa Oficial del Estado Sonora Republica de Mexico (1924). Mexico, Sonora, Cananea municipio. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.21 -110.31; 1,413 m (4,636 ft) elevation. Located south of Sierra Vista, across the border, this was apparently a huge ciénaga in the past, but is now only a remnant. **S**
144. Unnamed Ciénega #3. Mapa Oficial del Estado Sonora Republica de Mexico (1924). Mexico, Sonora, Naco municipio. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.15 -110.05; 1,476 m (4,841 ft) elevation. Located southeast of Sierra Vista, AZ, 20.9 km south of the border, this spring-fed creek currently possesses a riparian woodland, but no ciénaga. **D**
145. Unnamed Ciénaga #4. Sivinski, Robert, pers. comm. (2013). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.726 -109.7028; 974 m (3,196 ft) elevation. This is a wet, living ciénaga 2.6 km to the northwest of the Artesia ciénaga. **F**

146. Unnamed Ciénaga #5. Anonymous, pers. comm. (2013). United States, New Mexico, unknown County. Aquatic ecoregion (river basin)—unknown. Located near Mule Creek, upstream and to the east of an archaeological site, there is currently a pond and small marshy area here supported by manmade constructions with abundant water and marshy vegetation. **R**
147. Unnamed Ciénaga #6. Anonymous, pers. comm. (2013). United States, New Mexico, unknown County. Aquatic ecoregion (river basin)—unknown. This is near another archaeological site, likely restorable. **R**
148. Unnamed Ciénaga #7. Anonymous, pers. comm. (2012). United States, New Mexico, unknown County. Aquatic ecoregion (river basin)—unknown. We were informed of this functioning ciénaga at an Audubon meeting in Deming, NM, but the person worried that the property owners would not authorize disclosure. When he failed to follow up, the authors presumed the owners declined to give permission. **F**
149. Unnamed Ciénaga #8. Anonymous, pers. comm. (2013). United States, New Mexico, unknown County. Aquatic ecoregion (river basin)—unknown. Coordinates: m (ft) elevation. The authors were informed of this functioning ciénaga at an Audubon meeting in Deming, NM, in 2013. The person who informed us of the ciénega's existence worried that the property owners would not authorize disclosure. The informant failed to follow up and we presume the owners declined to give permission. **F**
150. Unnamed Ciénaga #9. Varner, Nick, pers. comm. (2014). United States, New Mexico, Grant County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.8823 -108.2276; 2,046 m (6,712 ft) elevation. Located 12.9 km (8 mi) north of Silver City, this is a 3.7 m (12 ft)-diameter, spring-fed pool of water atop a 107 m (351 ft)-deep cave with a side drift that is said to go south at least 30 m (98 ft). Located on a 0.8 ha (1.9 ac) private residential property next to an old mine shaft just north of Pinos Altos, it is fenced in a manner to allow wildlife access. We believe this ciénaga has never before been included in published ciénaga lists. The landowners are interested in its importance and preservation. This ciénaga surely was named, but that information is lost and now the ciénaga could very well bear the name Bear Creek Ciénaga because a creek by that name is nearby, or Varner Ciénaga, bearing the name of the current owners. **F**
151. Water of the Dead-Klondike Ciénaga. Hendrickson and Minckley (1985). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.80 -110.28; 1,127 m (3,698 ft) elevation. Located 40.2 km (25 mi) northeast of San Manuel, this location is a dry wash and farm fields, and no longer a ciénaga. **D**
152. Whitewater Draw Ciénega Minckley et al. (2013). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Guzman—Samalayuca. Coordinates: 31.468 -109.702; 1,223 m (4,012 ft) elevation. This location is 20.9 km (13 mi) northwest of Douglas and 43.5 km (27 mi) west of Adobe Double Elementary School near White Water Draw, a watercourse with the appearance on Google Earth of vegetation. Although there is no ciénaga at this location, due to its 483 m distance from the draw, and nearby features that seem to be watered on Google Earth, this ciénaga appears to be restorable. **R**
153. Whitlocky's Ciénaga. Minckley and others (2013). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.56 -109.29; 1,077 m (3,534 ft) elevation. This area currently looks like a playa bottom, and no ciénaga occurs here now. **D**
154. Willow Springs. Sivinski, Robert, pers. comm. (2013). United States, New Mexico, Socorro County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 33.8105 -106.9778; 1,631 m (5,350 ft) elevation. Located approximately 29 km (18 mi) southwest of Socorro. **S**
155. Williamson Valley Ciénega. Minckley et al. (2013). United States, Arizona, Yavapai County. Aquatic ecoregion (river basin)—Gila. Coordinates: 34.825 -112.633; 1,393 m (4,571 ft) elevation. Located 33.8 km (21 mi) northwest of Prescott, this site is in a large agricultural operation with an adjacent 6.4 km (4 mi)-long riparian ribbon that appears on Google Earth to end where large fields are wet. There does appear to be a small body of water near the site and with all the farming, surely there is water available for restoration. **R**

The following seven waters are recognized as ciénagas on earlier lists but are better thought of as wet, high mountain meadows, above 2,100 m (7,000 ft). We note them below to apprise the reader that we are aware of their existence and that they have been excluded from our list above and not overlooked.

- Barfoot Springs. Minckley et al. (2013). United States, Arizona, Cochise County. Aquatic ecoregion (river basin)—Gila. Coordinates: 31.917 -109.279; 2,515 m (8,250 ft) elevation.
- Bear Wallow Ciénaga (also known as: locally Bill Lewis Cienaga, Jennings, and High Peak Ciénega). Minckley et al. (2013). United States. Aquatic ecoregion (river basin)—Gila. Coordinates and elevation unknown. This is a small marshy area in Catron County, NM, just east of Bear Wallow Mountain, that still has marsh and aquatic vegetation.
- Bush Valley Ciénaga (also known as: Alpine Cienaga). Hayes, Frank, pers. comm. (2014). United States, Arizona, Apache County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.835954 -109.125583; 2,418 m (7,933 ft) elevation.
- Ciénaga—Unnamed. (Source unknown.) United States, New Mexico, Catron County. Aquatic ecoregion (river basin)—Gila. Coordinates: 33.6696 -108.5691; 2,725

m (8,939 ft) elevation. This was thought to be a boggy part of the Tularosa Creek valley near Aragon, NM, east of Reserve, but these coordinates may be incorrect. This point is too high, too steep, and with no wetlands.

- Highwater Ciénaga. Minckley et al. (2012). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.703 -109.884; 3,125 m (10,253 ft) elevation. Southwest of Safford, this is a high mountain meadow.
- Ciénaga Gregorio (also known as: St. Gregorio Lake and San Gregorio Reservoir). Pearce (1965) and Julyan (1996). United States, New Mexico, Rio Arriba County. Aquatic ecoregion (river basin)—Upper Rio Grande—Bravo. Coordinates: 36.04 -106.85; 2,874 m (9,428 ft) elevation. Julyan details the history of Gregorio Lake, 96.6 km north of Albuquerque, 9.7 km east of Cuba in Rio Arriba County. Once considered a ciénaga, the lake was created when the Cuba Water Users Association dammed Cienaga Gregorio, the name derived from a sheepherder who worked in the area before 1900, for irrigation.
- West Hospital Flat Spring. Jones, Cory, Sky Island Alliance, pers. comm. (2013). United States, Arizona, Graham County. Aquatic ecoregion (river basin)—Gila. Coordinates: 32.666 -109.876; 2,750 m (9,022 ft) elevation. This wetland is located in the Pinaleño Mountains in Graham County, AZ, just above Hospital Flat Campground along the Swift Trail (SR 366). The site consists of wet-meadow habitat with three narrow stream channels running through it.

Appendix C. Aridland Ciénagas and Springs in the Mid-19th-Century North American Southwest

The 64 spring and ciénaga sites identified here are located in the southeast portion of Arizona, southwest New Mexico, west Texas, and south of the international border, as shown on Captain Allen Anderson's 1864 Map of the Military Department of New Mexico and Lieut. Wheeler's Expedition, nach New-Mexico & Arizona, 1873, both of these found in Peter L. Eidenbach's (2012) *An Atlas of Historic New Mexico Maps, 1550–1941*, and several other sources. Anderson was the Acting Engineer Officer under the direction of Brigadier General James Carleton during the period when Carleton's field commander Kit Carson captured and interned the Mescalero Apaches and Navajos at Bosque Redondo. Wheeler mapped most of the lands west of the hundredth meridian for the U.S. Army between 1872 and 1884.

The purpose of this list is to document the occurrence of springs and ciénagas along travel routes in the International Four Corners Region at the time of the movement of American settlers westward. It is impossible to know either the number of springs or those that supported ciénagas because of their large numbers and because state-level inventories have not been completed, fewer than half of the known springs are named, springs are poorly studied, and thousands no longer have water. The named springs in the western United States have been inventoried by state in Stevens and Meretsky (2008), with a total of 29,862 *ojos* (springs).

Waters bearing the words *Ojo,* Spr., Spring, Springs, and Cienaga reflect the term listed in the maps where we found them. The listing sequence of 1 through 64 is more or less from north to south or toward the international border, and from there, from west eastward. We have not included lagunas, rivers, creeks, streams, or other water features that appear not to meet the potential or criteria for a ciénaga or for a ground-fed water feature that may have formerly been a ciénaga. Only 8 of the 61 waters bear the name *ciénaga*, yet some—likely a good many—of the springs supported ciénagas.

It would require a tremendous effort and expense to assess both the desiccated and the wet remaining *ojos* in order to determine which springs may have supported ciénagas. Although most aridland ciénagas are associated with springs and other groundwater discharge, not all springs support ciénagas. At the time of the massive migration west, travel routes were dotted with *ojos* and an uncertain number of co-occurring ciénagas surely were already dewatered, unappreciated, or overlooked, and were never recorded by cartographers. It is unlikely that the number of o*jos* that supported ciénagas will ever be known, but there were certainly more than the 155 named ciénagas listed on the working inventory, Appendix B.

1. Ojo de los Cojotes (west of Tucson, AZ)
2. Ojo de Buzany (south of the int. border, AZ/NM line, SO)
3. Ojo de San Ignasio (south of int. border, east of Buzany, SO)
4. Cienegas de los Pimas (southeast of Tucson, AZ)
5. San Pedro Sprs. (southeast of Pimas, AZ)
6. Bear Spr. (southeast of Fort Grant, AZ)
7. Dove Spr. (south of Bear Spring, AZ)
8. Chamelcon Spr. (south of Dove, AZ)
9. Spring, unnamed (southwest of Fort Bowie, AZ)
10. San Bernandino Spr. (south of int. border, below Fort Bowie, SO)
11. Cienega Bonita (north of Fort Bowie, AZ)
12. San Luis Spr. (south of int. border, west of San Bernardino, SO)
13. Mangus Spring (north of Fort Tulerosa, NM)
14. Curizo Spr. (north of Fort Tulerosa, south of Mangus, NM)
15. Ojo del Lobo (northwest of Forts Conrad & Craig, NM)
16. Wolf Spring (northeast of Lobo, NM)
17. Horse Spring (south of Lobo, NM)
18. Gallo Spring (northeast of Fort Tulerosa, NM)
19. El Creston Cienega (south of Lobo, NM)
20. Cienega del Datil (south of Creston, NM)
21. Cienega del Guiso (north of Fort West, NM)
22. Cienega, unnamed (south of Fort West, NM)
23. Ojo, unnamed (south of Burro Mt., NM)
24. Coyote Spring (south of Cienaga Spring, NM)
25. Emory's Spr. (north of border in the Bootheel, NM)

26. San Francisco Spr. (south of int. border, southwest of Emory's, SO)
27. Ojo de Luera (west of Fort Conrad, NM)
28. Cienega de los Alamos (south of Luera, NM)
29. Ojo de los Mosquitos (across int. border, east of Bootheel, CH)
30. Carrizalillo Spring (north of int. border, east of Bootheel, NM)
31. Ojo del Pinesco (west of Fort McRae, NM)
32. Ojos Calientes (west of Fort McRae, NM)
33. Spr., unnamed (south of Pinesco & Calientes)
34. Ojos Calientes (same name, north of Apache, NM)
35. Cienega del Apache (north of Fort Horn, NM)
36. Ojo del Berenda (south of Apache, north of Fort Horn, NM)
37. Cook's Springs (at Fort Cummings, NM)
38. Ojos de los Adjustments (below int. border, southwest of Las Cruces, CH)
39. Sulphar Spring (west of Fort Craig, NM)
40. Nogal Spr. (south of Fort Craig, NM)
41. Ojo del Muerie (west of Fort McRae, NM)
42. Pond of Aleman (south of Fort McRae, NM)
43. Spring, unnamed (southeast of Fort McRae, NM)
44. Mal Pais Spr. (Salt) (east of Fort McRae, NM)
45. San Andres Spr. (north of Las Cruces)
46. Ojo de San Nicolas (north of Las Cruces, NM)
47. Ojo de San Augustine (east of Las Cruces, below Nicholas, NM)
48. Ojo Soledad (east of Las Cruces, south of Nicholas, NM)
49. Spring, unnamed (south of int. border, near El Paso, CH)
50. Perdido Spr. (east of El Paso, TX)
51. Ojo del Cuervo (east of El Paso, TX)
52. Eagle Spr. (east of Fort Guitman, TX)
53. Water Holes (east of Fort Guitman, TX)
54. Van Horn's Wells (east of Fort Guitman, TX)
55. Water Holes (east of Fort Guitman, TX)
56. Springs, Dead Man's Hole (west of Fort Davis, TX)
57. Spring, unnamed (west of Fort Davis, TX)
58. Spring, unnamed (west of Fort Davis, TX)
59. Leon Spr. (northeast of Fort Davis, TX)
60. Venado Spr. (southeast of Fort Stanton, NM)
61. Captain Pope's Well (north of Fort Davis, NM)